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AEDC-TR-67-174 M. A. Nelius

EXPERIMENTAL PERFORMANCE OF A 60-DEG-SLANT, SEGMENTED WALL, MAGNETOHYDRODYNAMIC ELECTRIC POWER GENERATOR

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ARO, Inc.

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ROCKET TEST FACILITY
ARNOLD ENGINEERING DEVELOPMENT CENTER
AIR FORCE SYSTEMS COMMAND
ARNOLD AIR FORCE STATION, TENNESSEE

NOTICES

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FOREWORD

The test program reported herein was conducted at the request of the Aeronautical Systems Division (ASD), Air Force Aero-Propulsion Laboratory (AFAPL), Air Force Systems Command (AFSC), Wright-Patterson Air Force Base, Ohio, for the University of Tennessee Space Institute (UTSI) under Program Element 6240521F.

The results of the test were obtained by ARO, Inc. (a subsidiary of Sverdrup & Parcel and Associates, Inc.), contract operator of the Arnold Engineering Development Center (AEDC), AFSC, Arnold Air Force Station, Tennessee, under Contract AF33(615)-2691. The test was conducted in Propulsion Research Area (R-2C-4) of the Rocket Test Facility (RTF) under ARO Project No. RW0637 from October 21, 1966, until February 6, 1967, and the manuscript was submitted for publication on August 8, 1967.

Information in this report is embargoed under the Department of State International Traffic in Arms Regulations. This report may be released to foreign governments by departments or agencies of the U. S. Government subject to approval of Air Force Aero-Propulsion Laboratory (APIE-2), or higher authority within the Department of the Air Force. Private individuals or firms require a Department of State export license.

This technical report has been reviewed and is approved.

Joseph R. Henry
Lt Col, USAF
AF Representative, RTF
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Leonard T. Glaser
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Director of Test

ABSTRACT

A test program was conducted on a 60-deg-slant, segmented wall, magnetohydrodynamic generator. The generator channel was 48 in. in length with an inside width of 2 in., and diverged from 4 in. in height at the channel inlet to 6 in. in height at the channel exit. The plasma was provided by a gaseous oxygen/RP-1 combustor with a Mach number 1.6 nozzle. The propellants were seeded with potassium hydroxide (KOH) dissolved in ethyl alcohol to produce a high ion concentration in the exhaust stream. The generated power was dissipated through a resistor load bank with a variety of parallel and series resistance configurations. Operating conditions were nominally as follows: combustor chamber pressure, 46 psia; KOH concentration, from 0 to 1.8 percent of total propellant weight flow; magnetic field, 20,000 gauss; and load bank resistance, from 0 to 61.5 ohms. Tabulations of combustor performance data and of the generator electrical data are presented.

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SECTION I
INTRODUCTION

A magnetohydrodynamic (MHD) electric power generator is classed as a direct energy conversion device. Ionized gas flowing at high velocity through a channel is acted upon by a transverse magnetic field to produce an electromotive force (emf) perpendicular to the velocity vector and the magnetic field vector. The same physical principles are involved in an MHD generator as in a conventional generator except that conducting gases replace the metallic conductors of the rotor.

The University of Tennessee Space Institute (UTSI) is currently engaged in a research investigation of parameters governing the performance of open cycle MHD devices. The program is designed to provide correlation between theoretical and experimental performance of several types of MHD generators in order to establish basic generator design criteria. The scope of the experimental effort includes a parametric study to optimize the performance of 45-, 60-, and 75-deg-slant, Hall and Faraday generator channels operating at various gas dynamic conditions, electrical loads, and magnetic fields. The walls of each of the channels are segmented to reduce the effect of the Hall field.

The test program reported herein was conducted in Propulsion Research Area (R-2C-4) of the Rocket Test Facility (RTF). The RTF personnel were responsible for design and fabrication of the combustor and associated propellant, instrumentation, and exhaust systems. The channel, magnet, diffuser, load banks, and electrical meters were supplied by UTSI.

This report presents the data obtained from the 60-deg-slant, segmented wall MHD generator phase of testing. A description of the combustor, channel, magnet, and associated systems is given, and the methods used to obtain the required measurements are presented. Results of an earlier test program which utilized a vertically segmented wall (Hall) and a diagonally segmented wall (45-deg) MHD generator channel are presented in AEDC-TR-66-240.*

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*R. J. LeBoeuf and M. A. Nelius. "Experimental Performance of Two Segmented Wall Magnetohydrodynamic Electric Power Generators," AEDC-TR-66-240, January 1967.

SECTION II
APPARATUS

2.1 TEST ARTICLE

The test article consisted of a combustor, an MHD channel and diffuser, a magnet, and supporting systems. These components are described in detail in the sections to follow.

2.1.1 MHD Generator

The MHD generator channel (Fig. 1, Appendix I) is nominally 48 in. long with outside dimensions of 3.75 in. wide by 10.28 in. high. The inside dimensions are 2 in. wide by 4 in. high at the inlet with the side walls parallel and the top and bottom walls diverging to 6 in. high at the exit. The 36-in. active portion of the channel (conforming to the 36- by 6-in. magnetic field cross section) is assembled from several individually insulated wall segments, each segment acting as an electrode. The remaining 12 in. of channel length (nominally 6 in. at each end) is made of copper blocks (transition elements) insulated from each other to reduce eddy current effects. Each element and block is attached to the adjacent elements and blocks by ceramic-insulated, stainless steel screws.

The channel segments (Fig. 2) are 0.520-in.-thick copper slabs electrically insulated from each other by 0.018-in.-thick mica paper. The segments are inclined forward at 60 deg to the channel axis to form a laminate array 37 in. long, of which 0.5 in. at each end is part of the inactive portion (outside the volume between the 6- by 36-in. magnet pole faces) of the channel. The remaining 5.5 in. at each end is composed of insulated copper blocks (transition elements). Each of the 52 full segments is split at the middle to form a top and bottom element, also insulated from each other by 0.018-in.-thick mica paper. These elements and the 15 partial end segments comprise the electrodes.

The diffuser is made from 0.5-in. stainless steel, 2 by 6 in. in cross section and 24.5 in. in length. The diffuser adapts to the forward bulkhead of the spray chamber with a rubber slip joint seal and extends 8 in. into the spray chamber.

2.1.2 Magnet

The magnetic field is provided by a 20,000-gauss electromagnet (Fig. 3) and is directed normal to the vertical plane containing the axis

of the channel. The distance between the magnet pole faces is 3.96 in.; each face is 6 in. high by 36 in. long.

The magnet is of "C" frame construction with eight strip-wound coils; six coils have 48 turns each, and two coils have 55 turns each. Each coil is designed to conduct 600 amp for a total of 238,800 ampere turns. The magnetic field strength is presented in Fig. 4 as a function of current. Water cooling coils are installed adjacent to, but insulated from, the electrical coils. Cooling water is supplied at a rate of from 50 to 60 gal/min at a nominal inlet pressure of 70 psig. In case of accidental power failure, the energy stored in the magnetic field is dissipated through a 0.040-in. spark gap located in the electrical terminal box (Fig. 3a).

Electric power to the magnet is supplied by fifteen 400-amp, 40-v d-c power supplies connected in five parallel arrays of three each in series (Fig. 5).

2.1.3 Load Bank

The electrical power generated by the MHD channel is dissipated as heat through four air-cooled load banks, each containing two hundred and fifty-two 1.4-ohm heater element resistors (Fig. 6). Each load bank is capable of dissipating 100 kw. The individual resistors are strapped to form the desired parallel and series arrangements for impedance matching to the channel electrical output.

2.1.4 Combustor

Ionized gas to the MHD generator is provided by a gaseous oxygen (GO_2)/RP-1 combustor (Fig. 7) operating at a chamber pressure of 46 psia and at a nominal oxidizer-to-fuel ratio of 2.8. A seeding agent consisting of a solution of potassium hydroxide (KOH) saturated in MIL-A-6091 ethyl alcohol (21-percent KOH by weight) is injected into the RP-1 upstream of the combustor to increase the exhaust gas electrical conductivity.

The propellants are injected into the chamber through a 0.9-in.-thick, stainless steel injector (Fig. 8). The RP-1/seed solution is injected through 0.04-in.-diam orifices located on radii of 0.63 in. (four orifices) and 2.75 in. (eight orifices) on the injector face. The RP-1 is injected axially through the inner ring orifices and inward at an angle of 30 deg to the combustor centerline through the outer ring orifices. The GO_2 is injected through fifty 0.22-in.-diam orifices located on three concentric rings between the inner and outer RP-1/seed spray

rings. Combustor chamber pressure is measured through an orifice in the injector face.

The 7.0-in.-diam by 14.0-in.-long, water-cooled combustion chamber was fabricated from 347 stainless steel. The chamber cooling water flow rate was nominally 30 lb_m/sec, which provided a water velocity through the cooling passage of 17 ft/sec with a water temperature rise during firing of approximately 7°F.

A water-cooled, stainless steel exhaust nozzle (Fig. 9) is bolted to the downstream end of the cylindrical combustion chamber. The circular-to-rectangular cross-sectional transition is accomplished in the converging subsonic nozzle section upstream of the throat. The contoured supersonic section diverges from 2.0 by 3.1 in. at the throat to 2.0 by 4.0 in. at the exit, providing an area ratio of 1.37 and a nominal exit Mach number of 1.6. The nozzle cooling water flow rate is 35 lb_m/sec, which provides a water velocity at the throat of 33 ft/sec with a water temperature rise during firing of approximately 5°F.

Engine ignition is provided by a hydrogen-air igniter assembly (Fig. 10). The hydrogen-air mixture is ignited by a spark plug and exhausted into the chamber through the center port of the injector. The total flow rate of the igniter reactants is approximately 0.11 lb_m/sec, and the air-to-fuel ratio is nominally 16.

2.2 INSTALLATION

The combustor, magnet, channel, and diffuser were installed in Propulsion Research Area (R-2C-4). A photograph and a schematic of the installation are shown in Fig. 11. The combustor was mounted on a support stand and connected to the facility propellant and coolant systems. The magnet was installed on the magnet support stand, and the channel was placed on a support stand between the magnet pole faces. The forward flange of the channel was aligned with and bolted to the combustor nozzle flange. The channel diffuser extends through the forward bulkhead of a spray chamber that contains one air spray ring and four water spray rings. A 12-in. exhaust duct is bolted to the downstream end of the spray chamber to direct the cooled exhaust gases into the facility exhaust ducting to be discharged into the atmosphere.

The spray chamber (Fig. 12) is a 36-in.-diam, 10-ft-long cylinder made of 1/4-in. mild steel. The air spray ring is located just forward of the diffuser exit plane (Fig. 11b) and provides a nonconducting shroud around the ionized exhaust gases to prevent electrical conduction to the

spray chamber walls until the exhaust gases are cooled below the ionization temperature. The four water spray rings cool the exhaust to a low temperature before it enters the exhaust duct and is exhausted to the atmosphere. The spray chamber is insulated against 2000-v potential from ground, and the supply lines and drain line are made of cotton braid rubber hose. The resistance to ground through the lines is about 1000 ohms with the 6-in. drain line full of cooling water.

2.2.1 Electrical

Figure 13 shows a typical electrical circuit used for the 60-deg-slant channel. The electrical measurements made were: (1) voltage across the load resistors, (2) current from channel electrodes to the load bank, and (3) current from the channel element top-to-bottom. The even-numbered segments 2 through 52 were shorted top-to-bottom, and the odd-numbered segments 3 through 51 were shorted top-to-bottom through ammeter shunts. Only segment 1 and the lettered partial end segments were electrically connected to the load bank and equipped with ammeters for measurement of both channel-to-load bank current and element top-to-bottom current. Current from the four segments at the upstream end and the four segments at the downstream end of the channel to the load bank was carried by 3/0 cable. Current from element top-to-element bottom and from element-to-load bank for all other segments was carried by No. 2 American Wire Gage (AWG) 600-v cable.

The shunt panel (Fig. 14) is an electrical interface between the channel and the load bank, containing low resistance (0.0005-ohm) shunts across which current between channel elements and between the channel and load bank is measured. Voltage taps and fuses to protect the meter circuits and load bank circuits are also provided in the shunt panel.

2.2.2 Propellant System

A schematic of the propellant system is shown in Fig. 15. The GO_2 is supplied from a 55,000-scf trailer charged at pressures ranging to 800 psia. The pressure is reduced and maintained at a value that provides the desired flow rate by an automatic pressure control system.

The RP-1 flow is supplied by and controlled from a 75-gal stainless steel tank pressurized with dry nitrogen. The pressure-fed alcohol-KOH seeding agent is injected into the RP-1 line upstream of the engine injector. All propellant systems incorporate provisions for purging the lines with dry nitrogen.

2.3 INSTRUMENTATION

Instrumentation is divided into two distinct groups - engine and spray chamber instrumentation (herein designated support equipment instrumentation) and channel and magnet instrumentation. Instrument ranges, recording methods, and system accuracies for all measured parameters are presented in Table I (Appendix II).

2.3.1 Support Equipment Instrumentation

Instrumentation is provided to measure combustor chamber pressure, injector pressures, propellant and seed flow rates, propellant tank pressures, combustion chamber and nozzle cooling water temperature rise, and spray chamber pressure.

Bonded strain-gage-type transducers are used to measure pressures. Copper-constantan thermocouple probes are used to measure cooling water inlet and discharge temperatures, and iron-constantan probes are used to measure propellant temperatures. Fuel and seed flow rates are measured with turbine-type flowmeters. The GO_2 flow rate is determined by a critical flow venturi located downstream of the pressure control system.

The output signal of each measuring device was recorded on independent instrumentation channels. Primary combustor data were obtained from two combustion chamber pressure channels (one 50- and one 100-psia), one oxygen venturi upstream pressure channel, two injector pressure channels (oxygen injector and fuel injector), one igniter pressure channel, two fuel flow channels, and two seed flow channels. The primary data were recorded as follows: Each pressure output signal was transmitted to a millivolt-to-frequency converter. A magnetic tape system, recording in frequency form, stored the signal from the converter for reduction at a later time by an electronic digital computer. The computer provided a tabulation of average absolute values for each 0.2-sec time increment. The fuel and seed flow signals were transmitted through wave shaping converters to the magnetic tape systems. A photographically recording, galvanometer-type oscillograph recording at a paper speed of 10 in./sec provided an independent backup of all primary instrumentation channels. The secondary data were recorded on magnetic tape from a multi-input, high-speed, analog-to-digital converter at a scan rate for each channel of 75 times/sec. Playback of this tape on the IBM 360 and Raytheon 520 computers provided a tabulation of average absolute values for each 0.2-sec time increment.

2.3.2 Channel and Magnet Instrumentation

Instrumentation is provided to measure channel wall pressures (Fig. 2), generated voltages and currents, and magnet input power. Channel wall pressures are measured using bonded strain-gage-type transducers (0- to 30-psia).

The output signal of each channel pressure transducer was recorded on magnetic tape from a multi-input, high-speed, analog-to-digital converter at a scan rate for each output signal of 75 times/sec. Playback of this tape on the Raytheon 520 computer provided a tabulation of average absolute values for each 0.2-sec time increment. Use of this equipment was made possible by using electrically nonconducting tubing from the high potential channel to the ground potential transducers.

Generated voltages and currents and magnet input voltage and current were displayed on an array of meters located on a rack-mounted meter panel (Fig. 16) and insulated for 2000-v potential to ground. The data from these meters were recorded photographically by a 70-mm camera that was timer actuated to provide photographs at approximately 1-sec intervals during a power generation firing. These photographs were time correlated with engine burn time by "camera pulses" recorded on the oscillograph.

SECTION III
PROCEDURE

The assembled 60-seg-slant MHD channel was received at AEDC on October 7, 1966. The channel was installed, and power generating runs were made for a variety of magnetic field strengths, electrical loads, and seed flow rates.

The sequence of events for each firing is accomplished automatically by use of electric timers and relays. For a typical firing, the sequence is as follows:

t_0	Fire button actuated manually
$t_0 + 1$	Igniter air valve open; spark plug begins to fire
$t_0 + 1.5$	Igniter hydrogen valve open
$t_0 + 4$	Propellant valves electrically energized
$t_0 + 5$	Engine ignition; igniter spark plug and propellant valves de-energized

t_0 + 5.5 Seed reaches chamber; power generation commences

t_0 + 12 Seed valve de-energized

t_0 + 14 Propellant valves de-energized; nitrogen purge through propellant lines initiated.

The purges are directed through the engine, channel, diffuser, and the facility exhaust and, in addition to clearing the propellant lines, help to cool the channel for the following firing. The purge continues until the firing panel is reset.

SECTION IV
RESULTS AND DISCUSSION

A 60-deg-slant MHD electric power generator channel was tested to determine the effect on generator performance of variations in external resistance loading, magnetic field strength, and seed concentration. The products of combustion from a GO_2/RP-1 combustor seeded with a saturated solution of potassium hydroxide and ethyl alcohol were supplied to the generator inlet at a Mach number of 1.6 and at a nominal total pressure of 46 psia.

This report contains the measured values of combustor chamber pressure and propellant flow rates, generator resistance loading, generator electrical currents and voltages, and generator power output as a function of load resistance. The conditions at which performance data were obtained are summarized in Table II. Only the last firing at a given condition is presented for a particular series since all firings except the last were considered conditioning firings. Generator performance varied as much as 25 percent between consecutive firings at a given set of test conditions. Data from 42 of the 126 firings accomplished are included. Also presented are the combustor operating characteristics.

4.1 COMBUSTOR OPERATING CHARACTERISTICS

The analog variations in chamber pressure, propellant flow rates, and injector pressures during a typical engine ignition are shown in Fig. 17. Also shown is the camera pulse trace that relates the time when generator electrical data were photographically recorded with combustor operational events. The times required for the RP-1 and the seed to reach the chamber after propellant valve actuation were 0.7 and

1.5 sec, respectively, at the nominal combustor operating condition. The seed flow lag time (1.5 sec) was intentionally long to prevent admittance of seed into the MHD channel prior to increase of channel wall temperature, thereby preventing electrically conducting seed residue from condensing on the cold walls of the channel.

The variations in chamber pressure and in RP-1, oxygen, and seed flow rates are presented in Fig. 18 for a typical firing. Seed flow was stopped approximately 3 sec prior to engine shutdown to ensure removal of all seed residue from the channel walls.

The average values of chamber pressure and oxygen, RP-1, and seed flow rate during the 1-sec period prior to seed flow shutoff (t_2 in Fig. 18) are presented in Table III. Time t_1 in Fig. 18 and in Table III represents the time from activation of the firing circuit to the initiation of chamber pressure increase. Since the time base for all data tabulated in this report is referenced from firing circuit energization, t_1 can be used for correlating events from combustor ignition.

The combustor operated at a nominal chamber pressure of 46 psia, total propellant flow rate of 1.75 lb/sec, and an oxygen-to-fuel ratio of 2.8. Characteristic velocity was nominally 5200 ft/sec. The combustion efficiency based on the theoretical performance of kerosene and oxygen propellants is estimated to be 92 percent, which provides a combustion chamber gas temperature of approximately 5000°F.

4.2 GENERATOR PERFORMANCE DATA

The measured values of individual channel resistance loads are presented in Table IV. Power was primarily extracted through one large center resistor connected between the eight electrodes at each end of the channel. The center 51 elements of the channel were not connected to the load bank.

Physical location and typical values of channel pressures during the 1-sec time interval prior to seed flow shutoff are shown in Fig. 19.

Typical channel electrical currents and voltages measured during the 1-sec period prior to seed flow shutoff are presented in Table V. Total generated power as a function of total load resistance is presented in Fig. 20. Channel total current, total voltage, and combustor chamber pressure variation are shown in Fig. 21 for a typical generating run. Sign conventions used were: (1) current from channel-to-load bank denoted positive, (2) current from top channel element-to-bottom channel

element denoted positive, and (3) increasing electrical potential above upstream channel potential denoted positive.

4.3 CHANNEL STRUCTURAL DURABILITY

Intense arcing was observed between the downstream channel transition elements and the channel support stand during firings 47. 3, 48. 14, and 56. 11. Arcing occurred only during firings in which high load bank resistances were used and was apparently caused by the resultant high voltage drop between the downstream end of the channel and the support stand.

Figure 22 shows typical damage caused by arcing. In each case, it was necessary to replace only the Teflon® insulating pad since the channel itself was not damaged.

After 126 firings with a total burn duration of 952 sec (at the conclusion of the 60-deg-slant phase of testing) the channel appeared to be in good operating condition.

APPENDIXES

I. ILLUSTRATIONS
II. TABLES

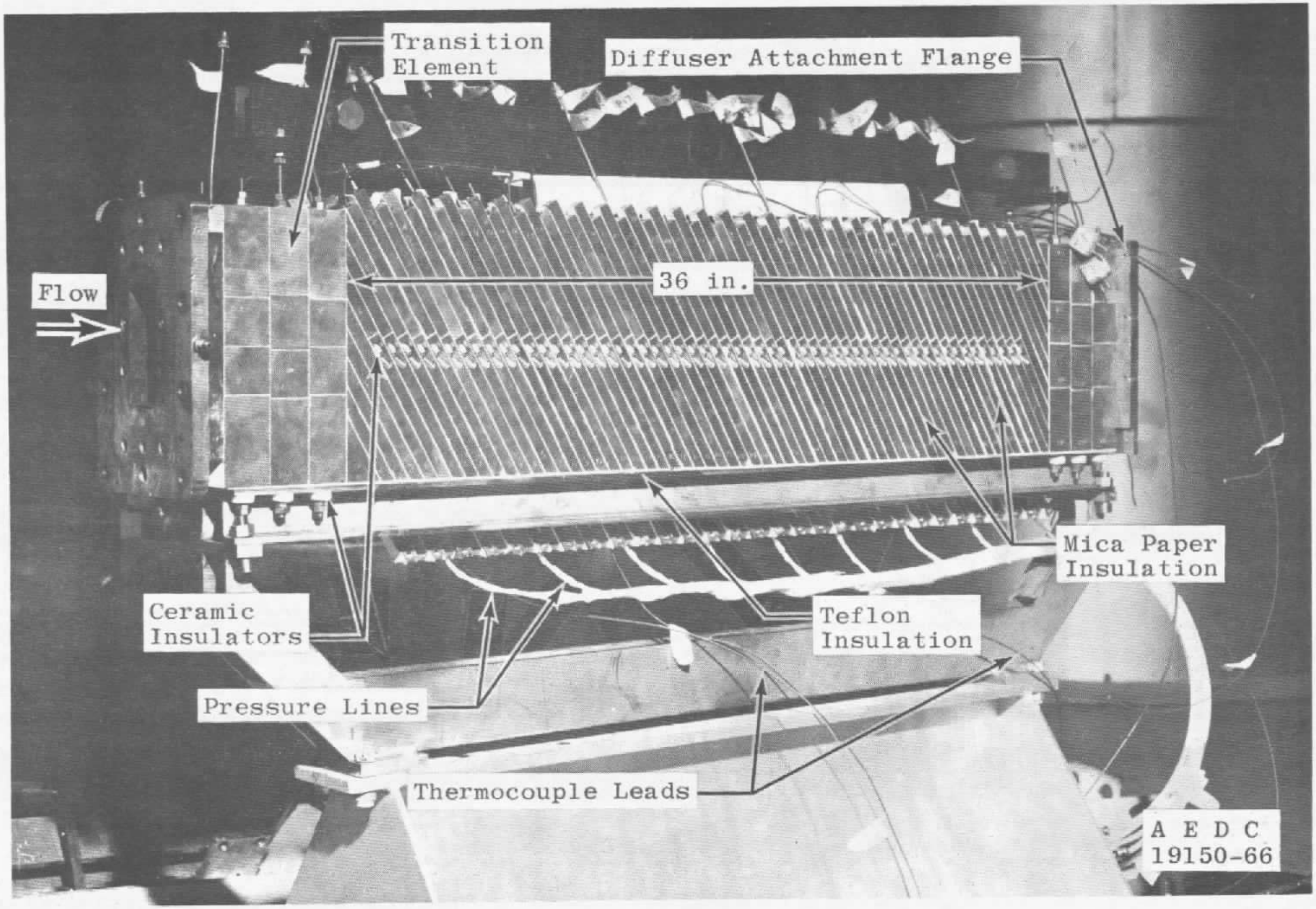


Fig. 1 Photograph of 60-deg-Slant Segmented Wall Channel

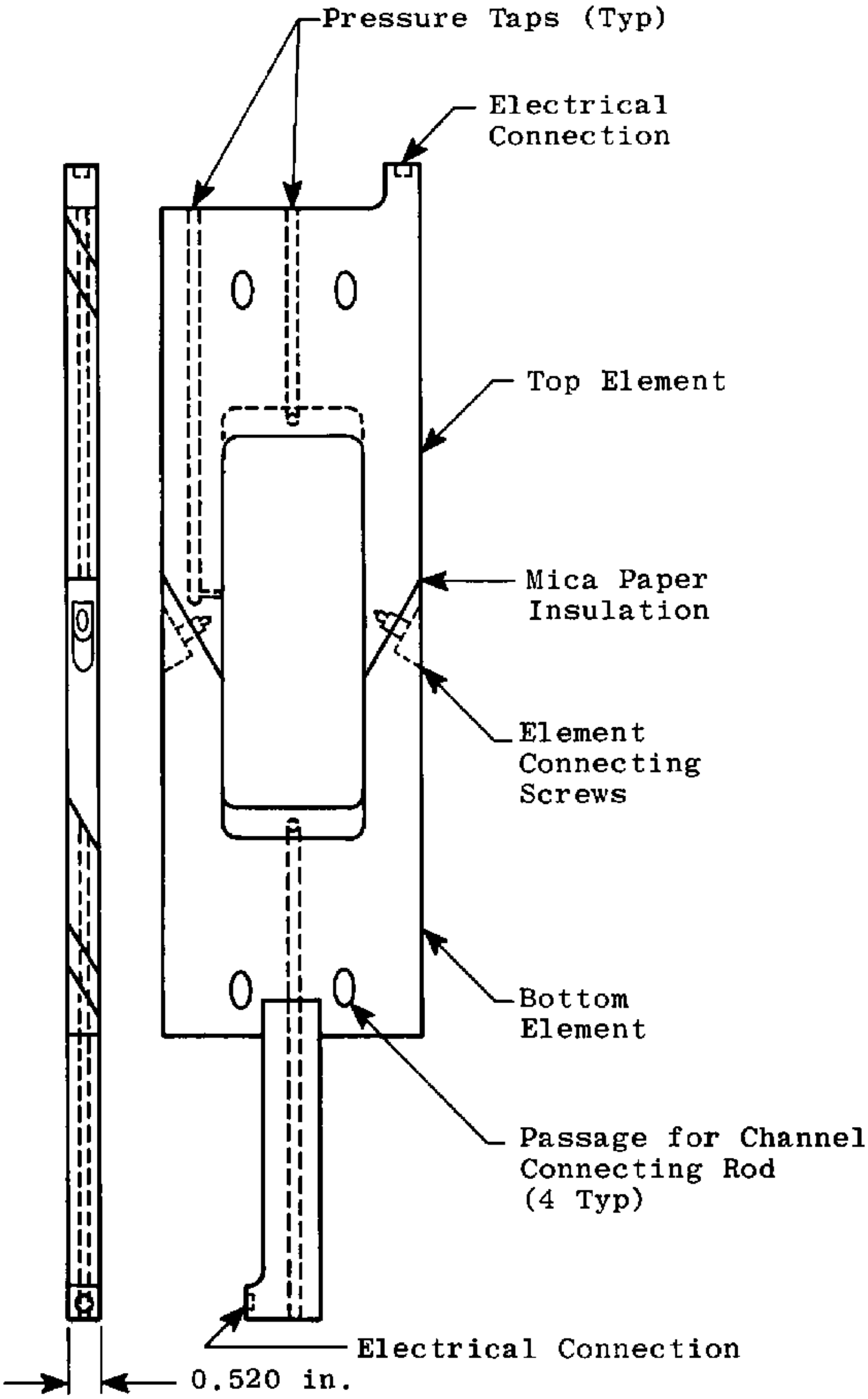
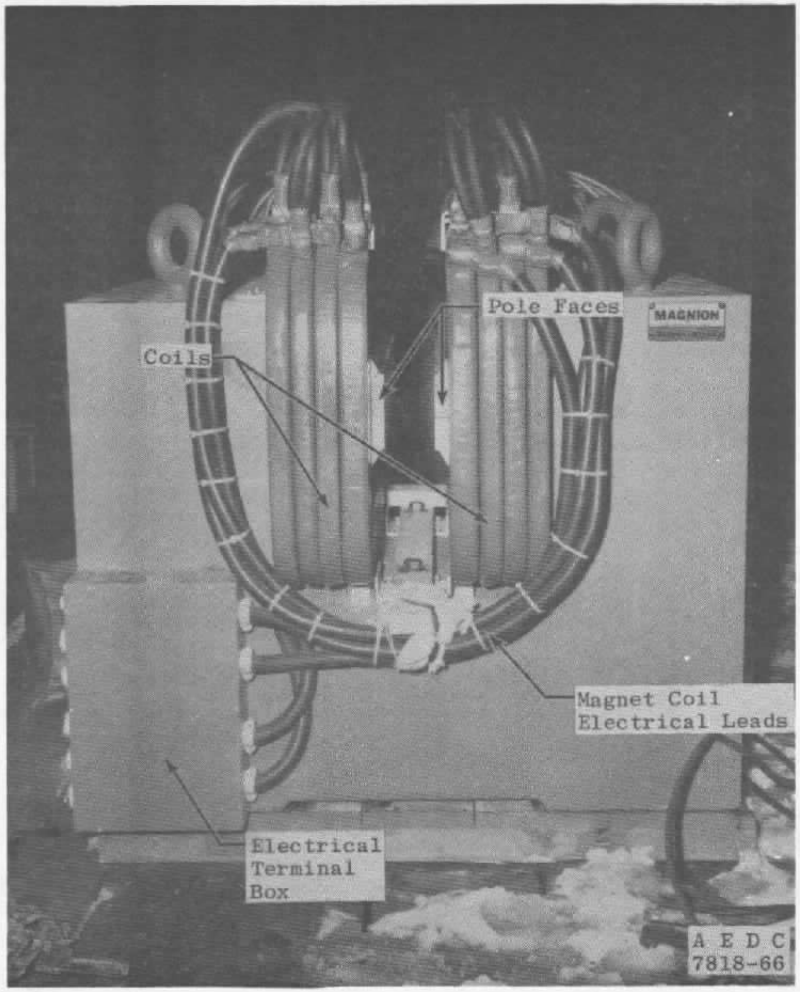
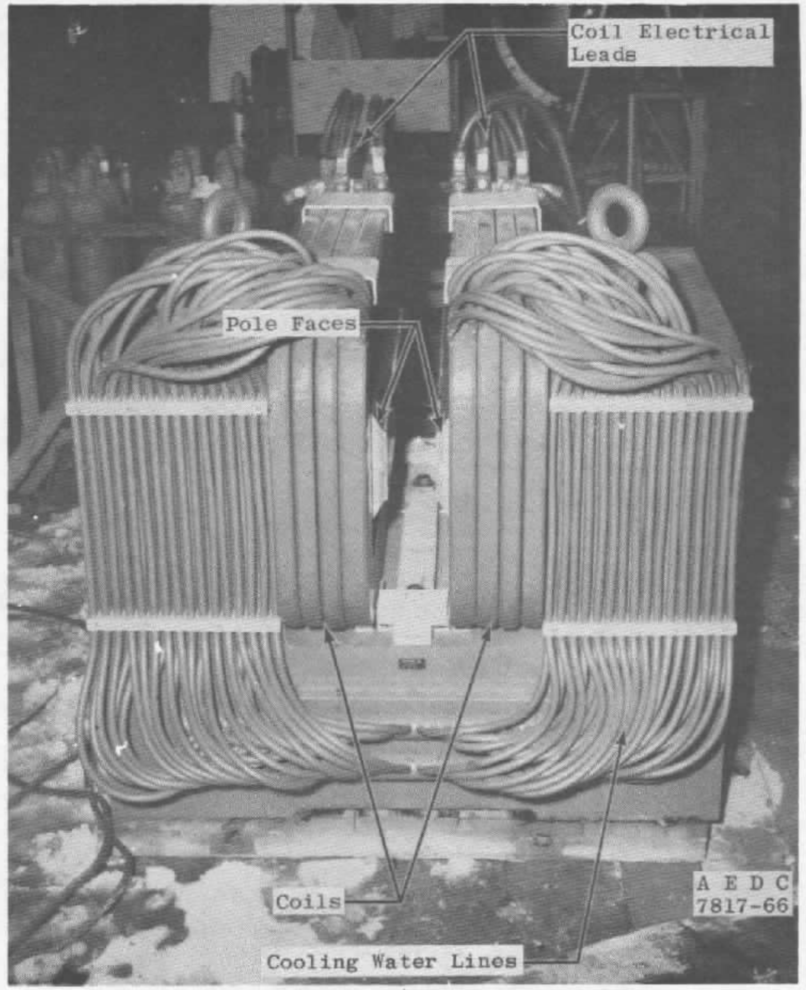


Fig. 2 Schematic of Typical 60-deg-Slant Channel Segment

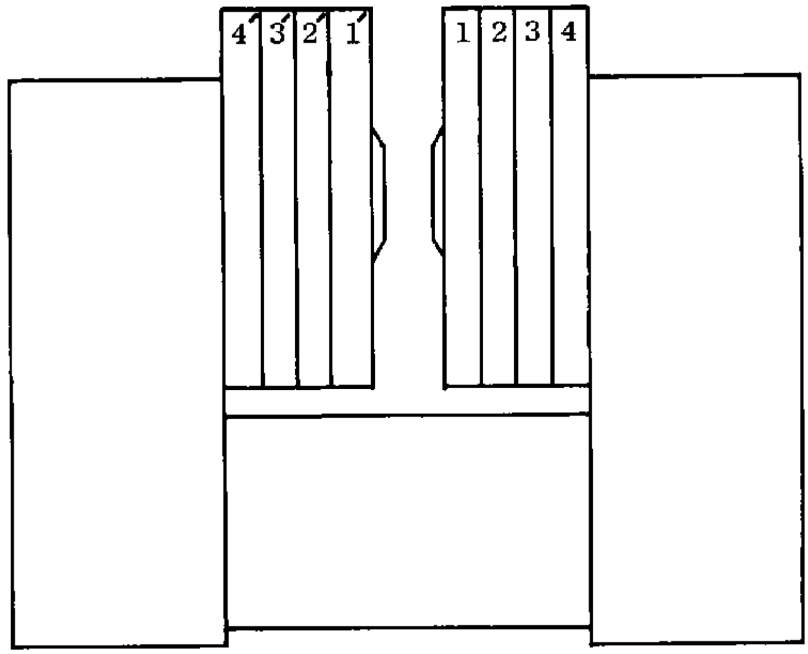


a. Photograph, Looking Upstream

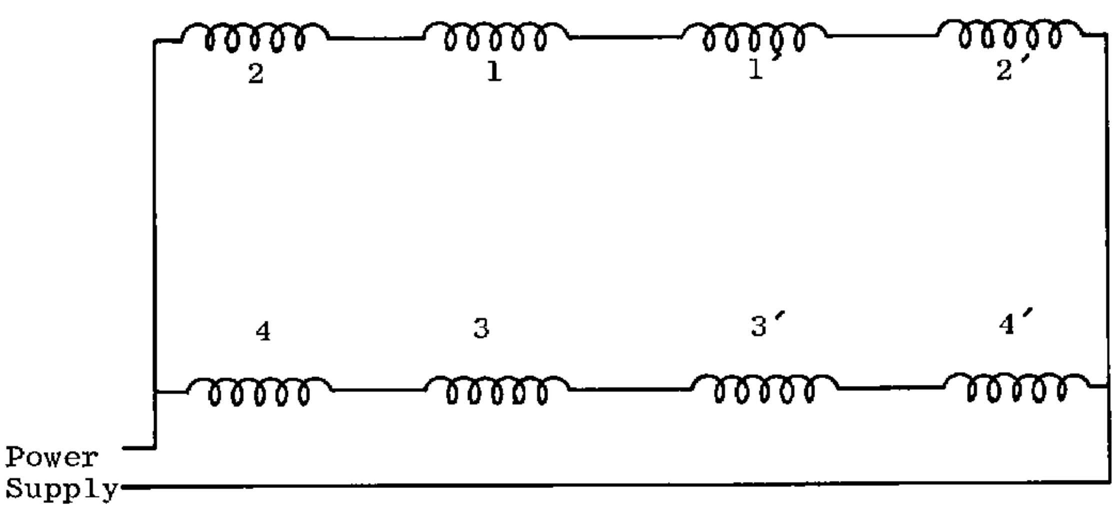


b. Photograph, Looking Downstream

Fig. 3 Electromagnet



Coil Locations
(Looking Upstream)



c. Coil Electrical Schematic

Fig. 3 Concluded

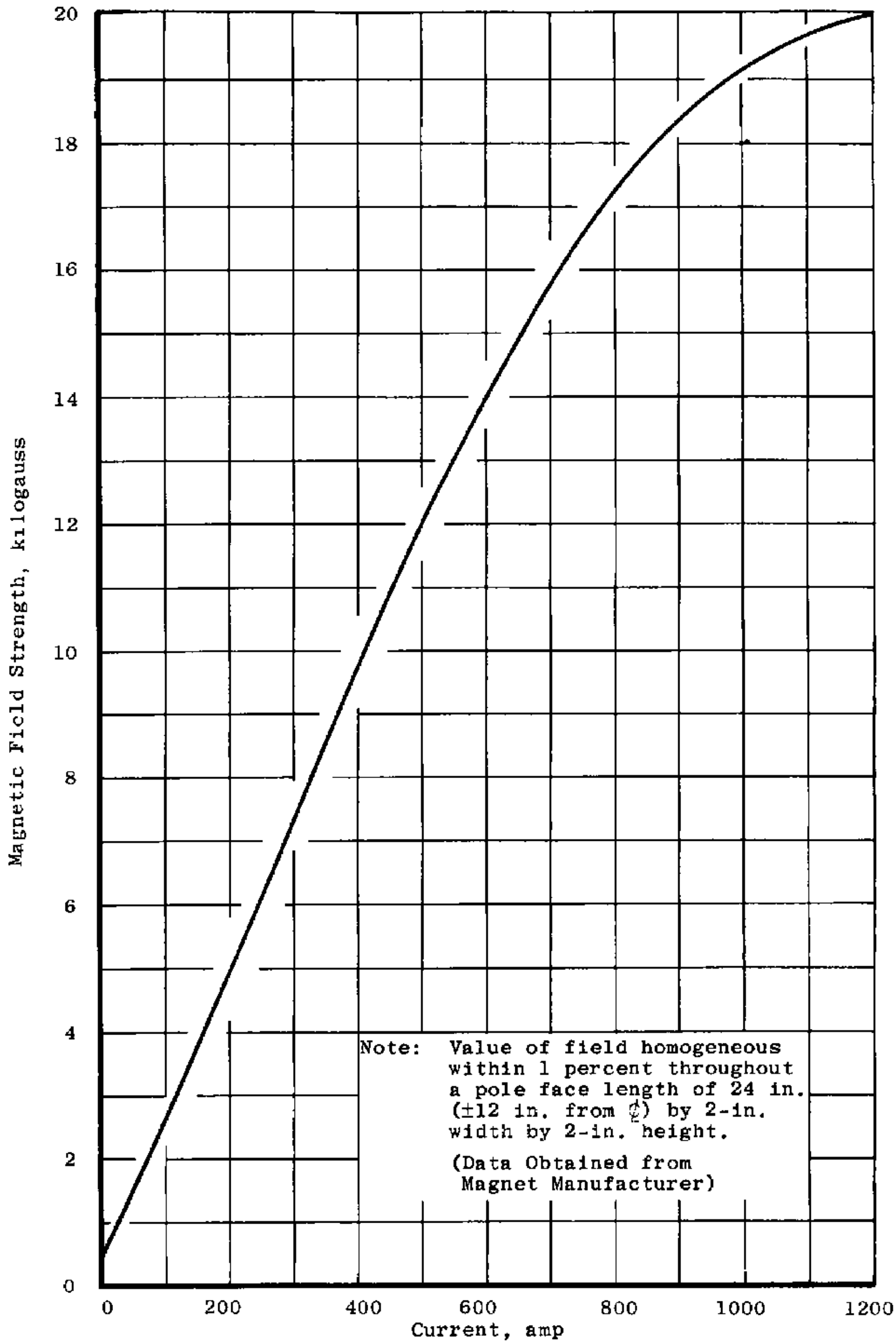


Fig. 4 Magnet Field Strength as a Function of Current

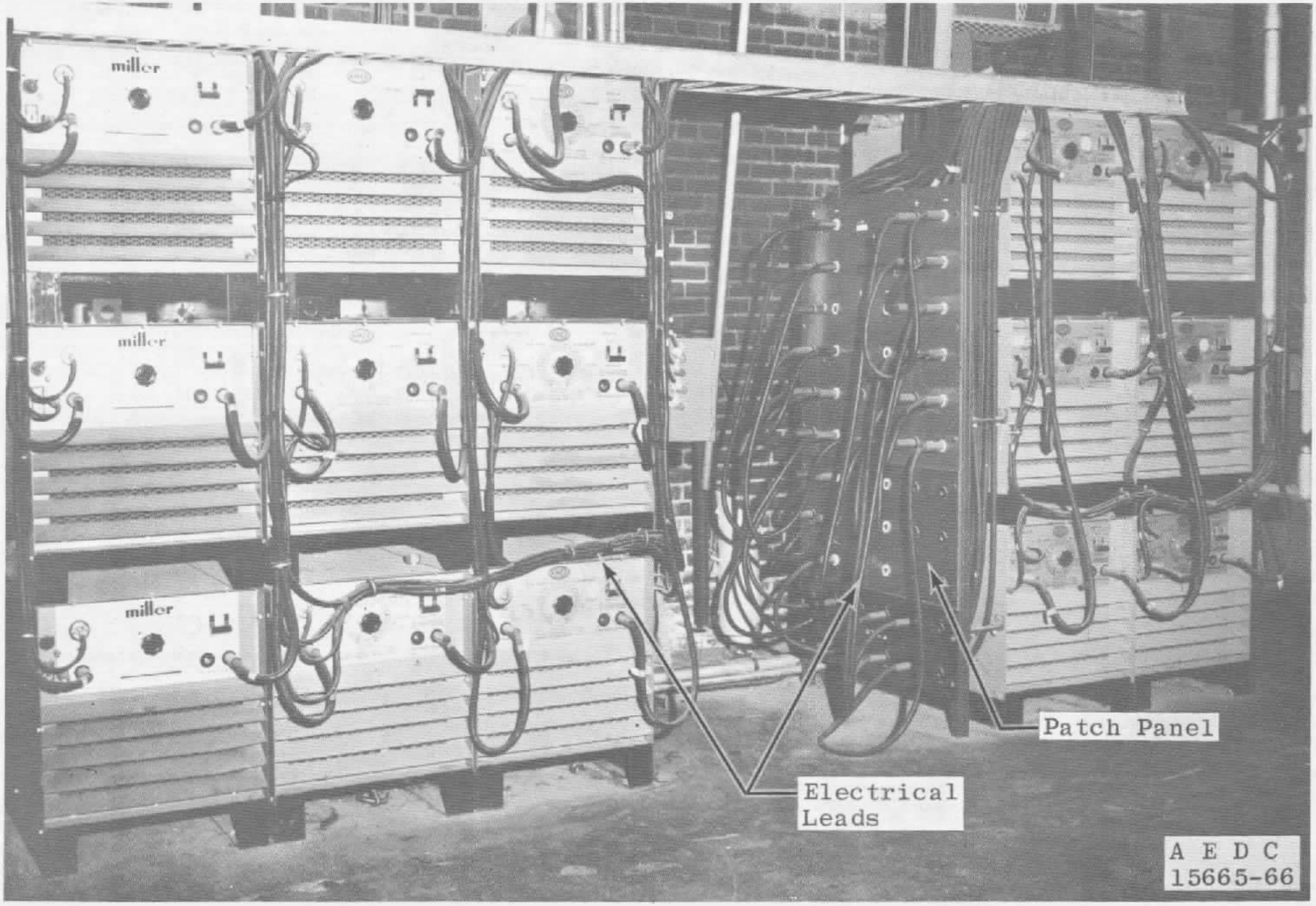
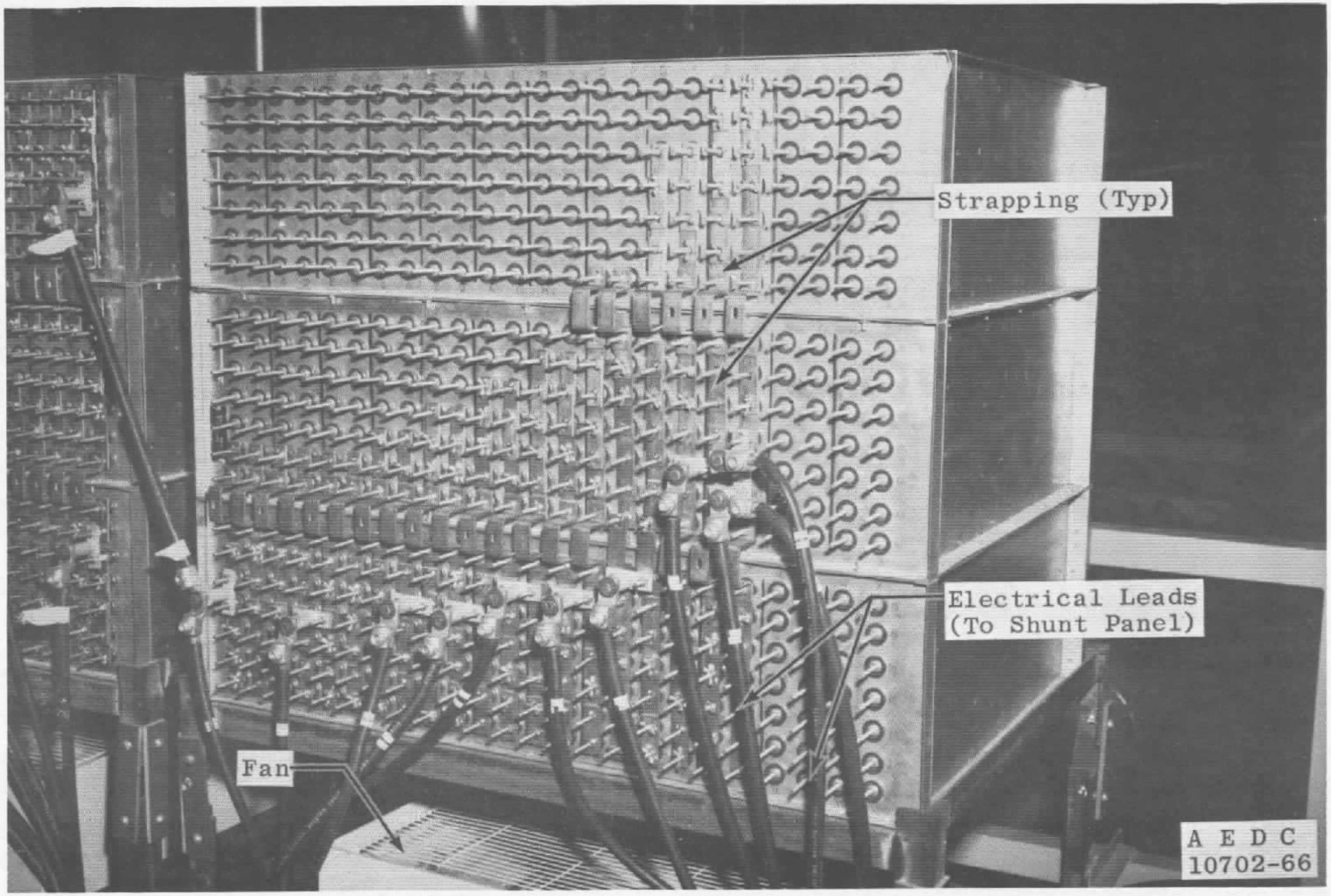
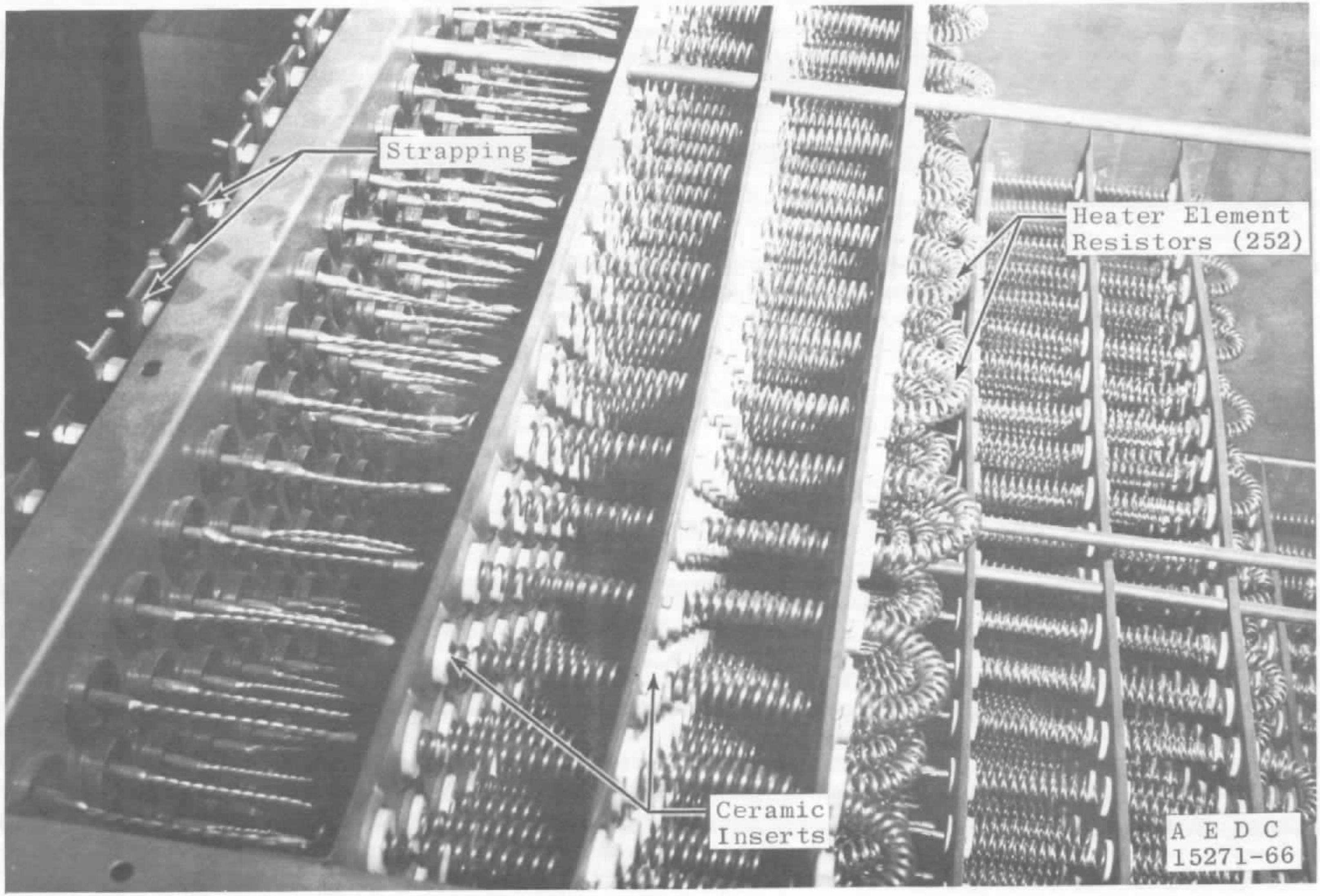


Fig. 5 Photograph of Magnet Power Supplies



a. Front View

Fig. 6 Photograph of Typical Load Bank Unit



b. Top View

Fig. 6 Concluded

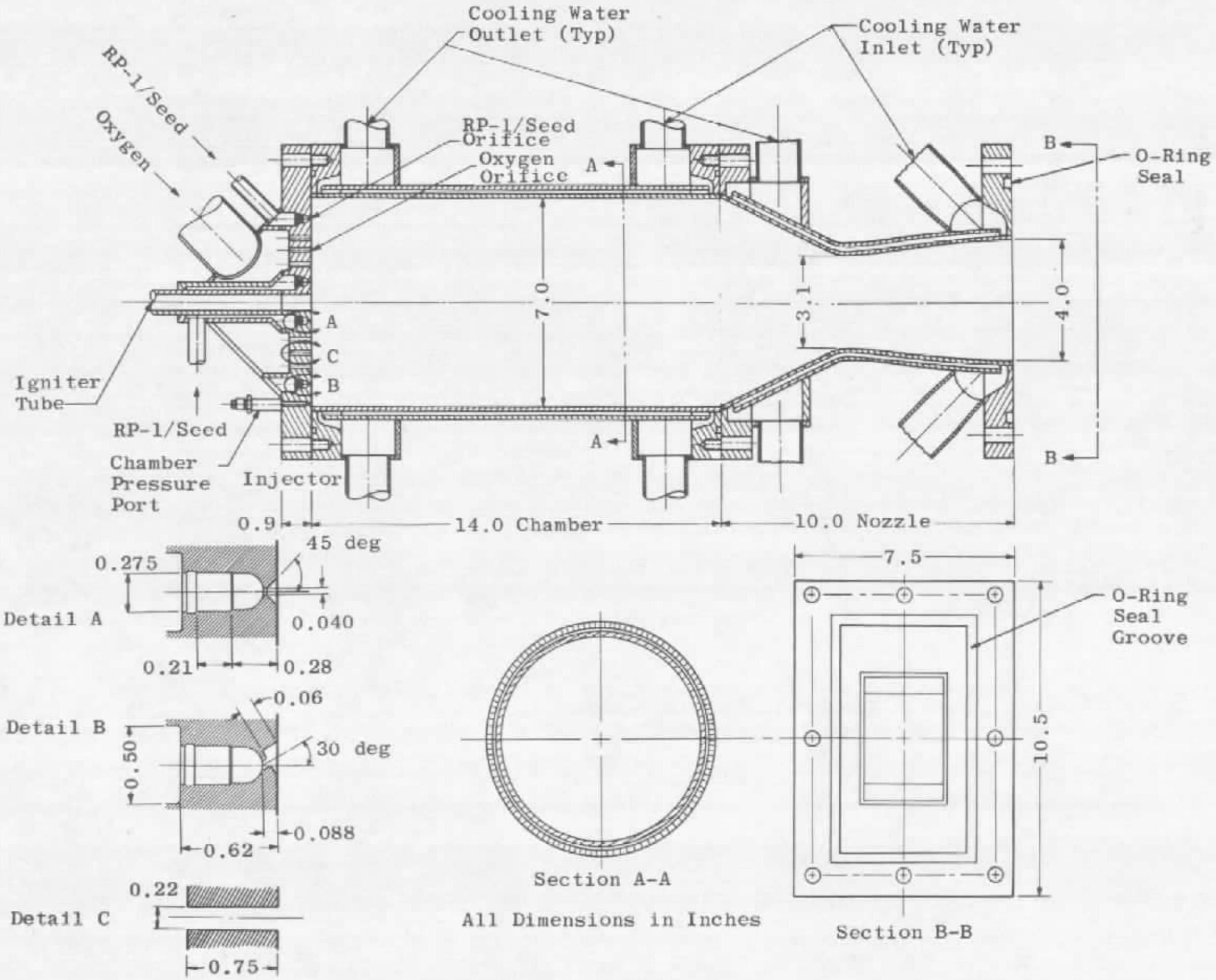


Fig. 7 Schematic of Combustor

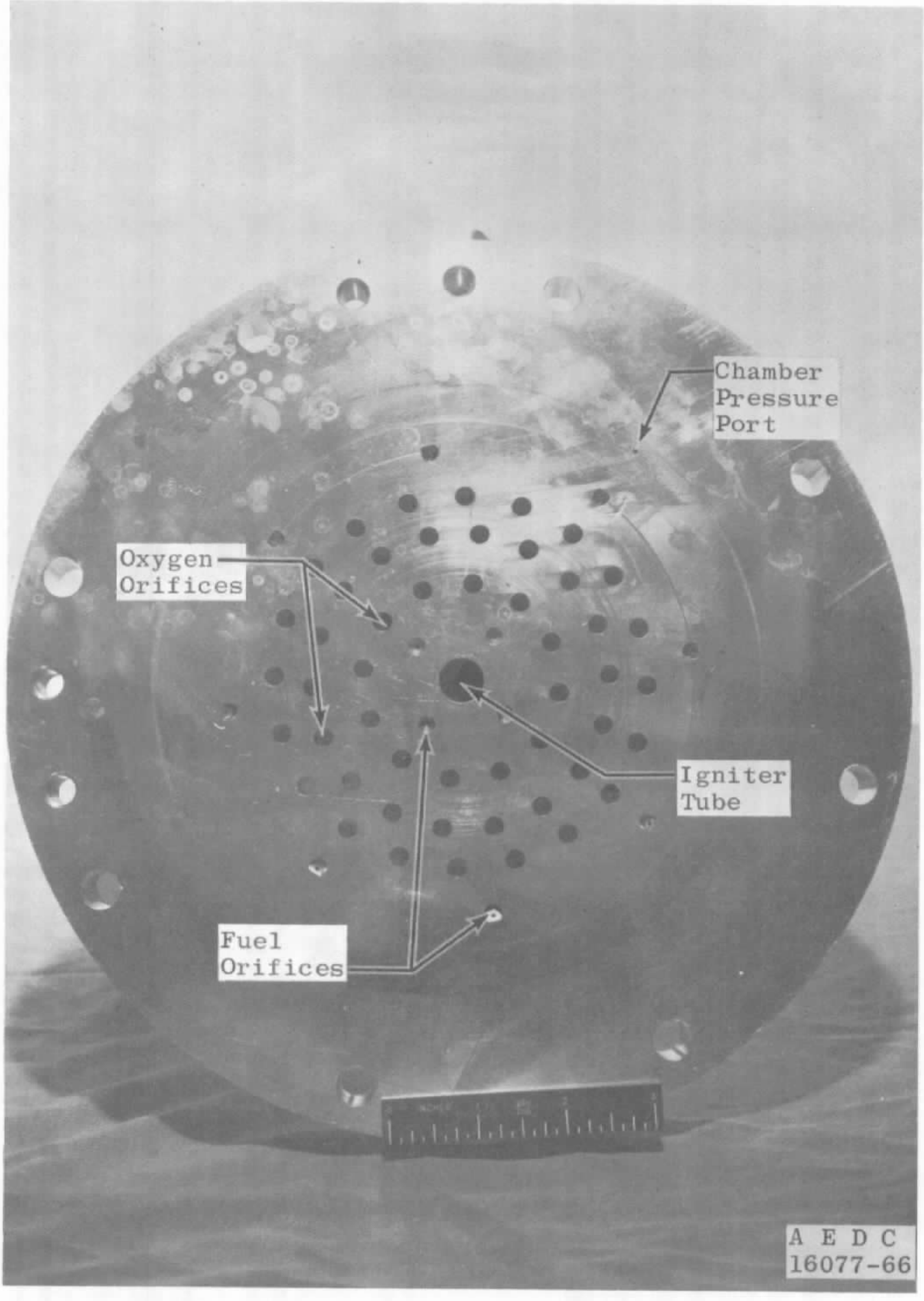
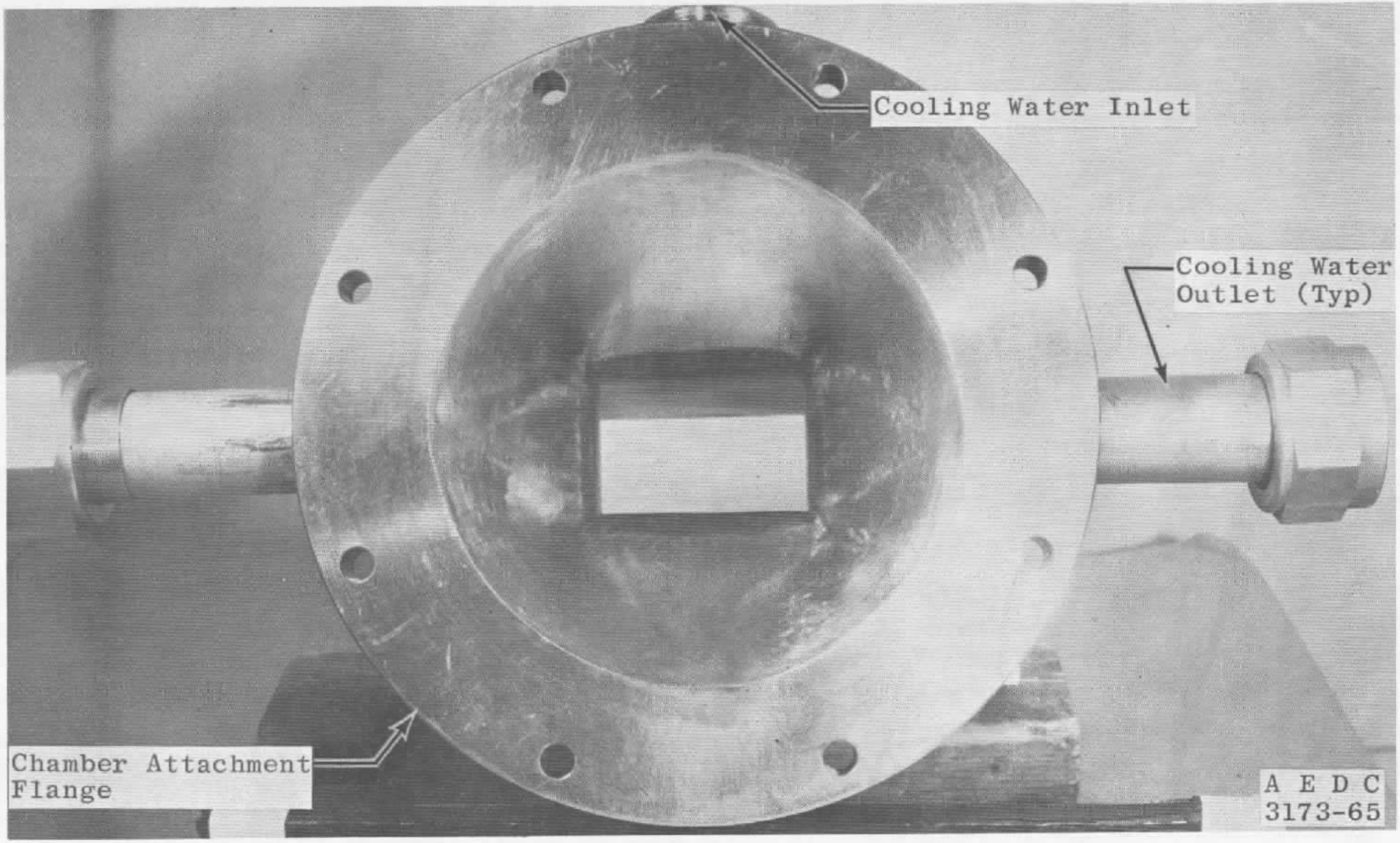
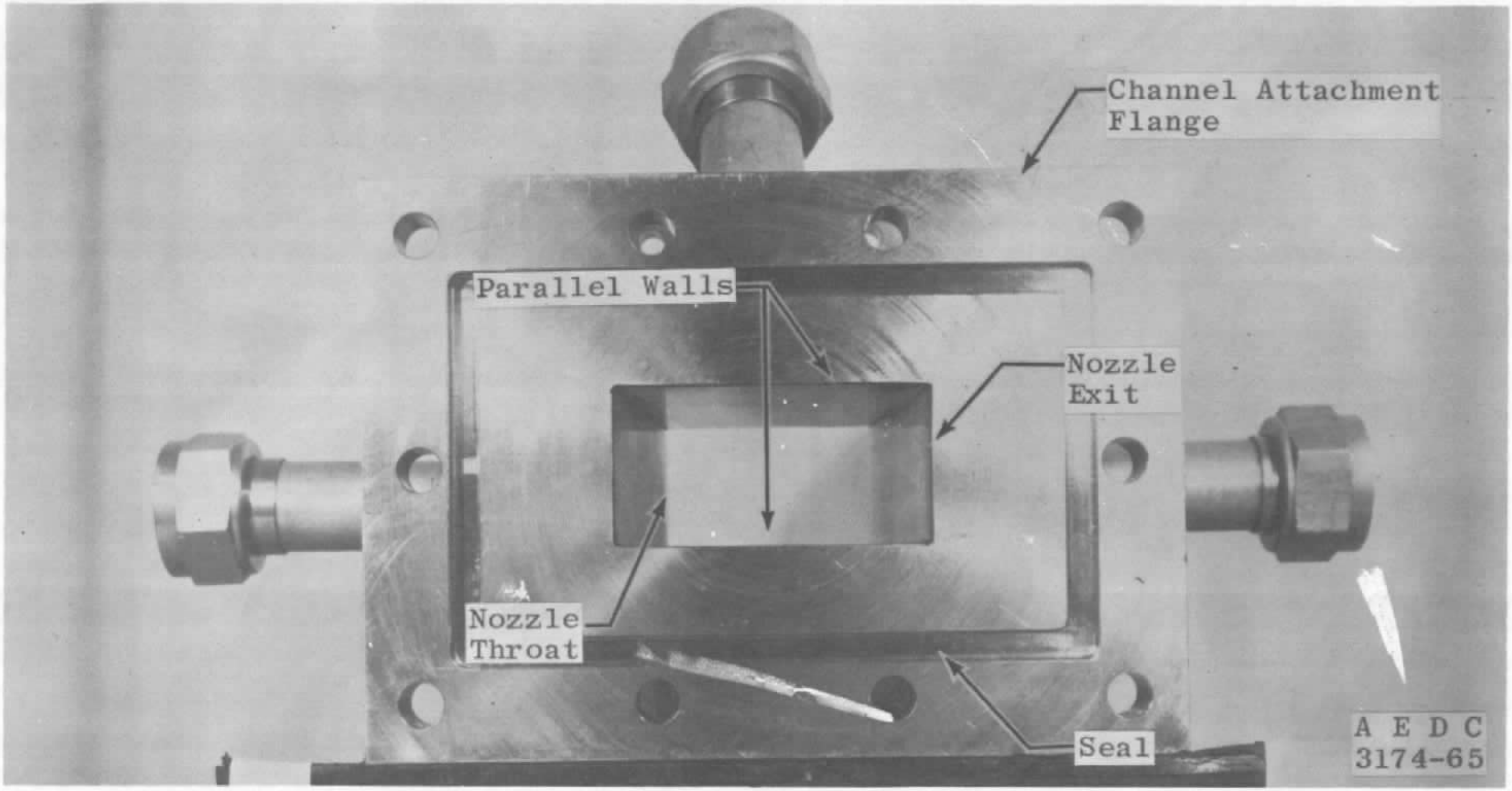


Fig. 8 Photograph of Injector



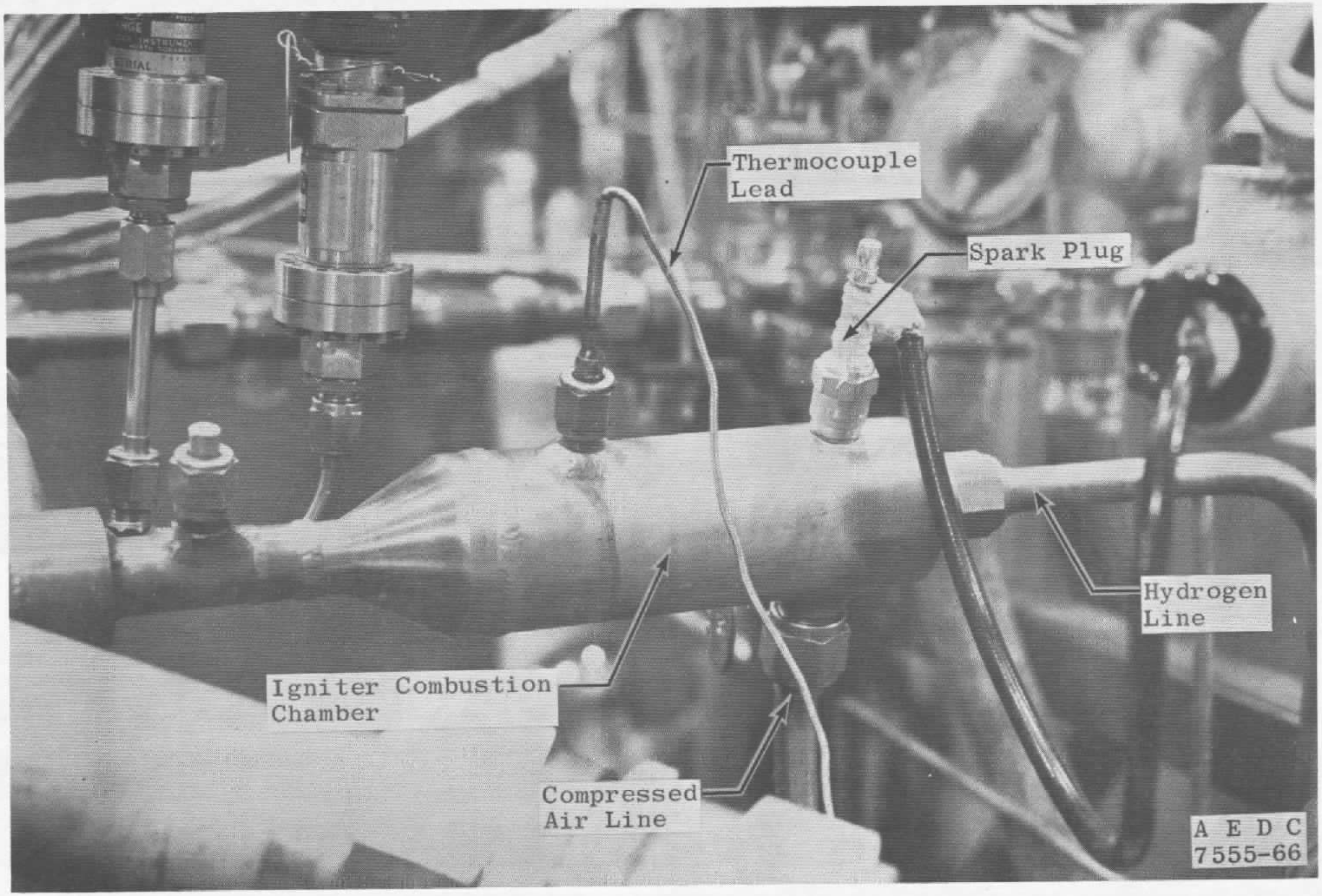
a. Looking Downstream

Fig. 9 Photographs of Water-Cooled Exhaust Nozzle Assembly



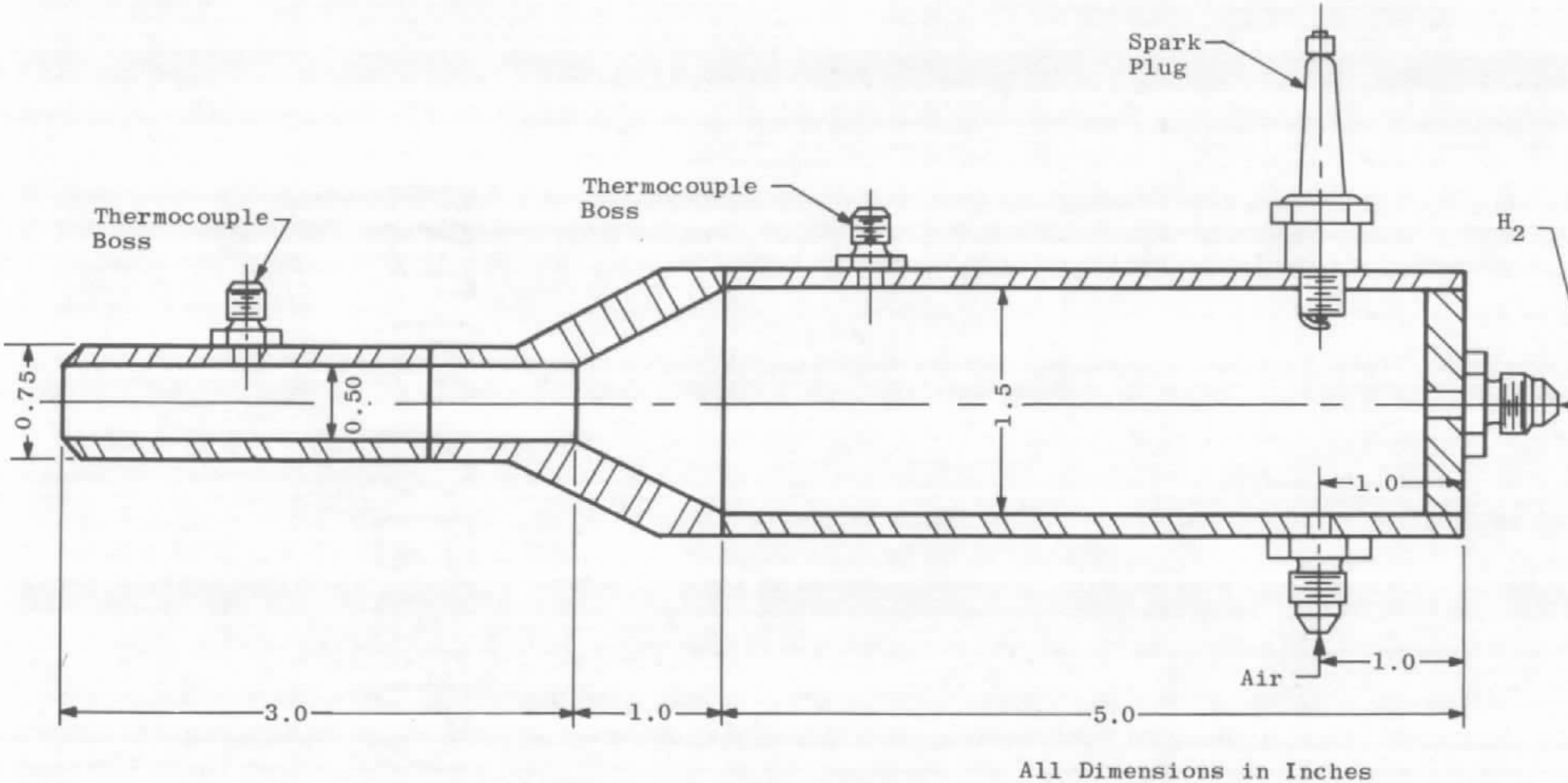
b. Looking Upstream

Fig. 9 Concluded



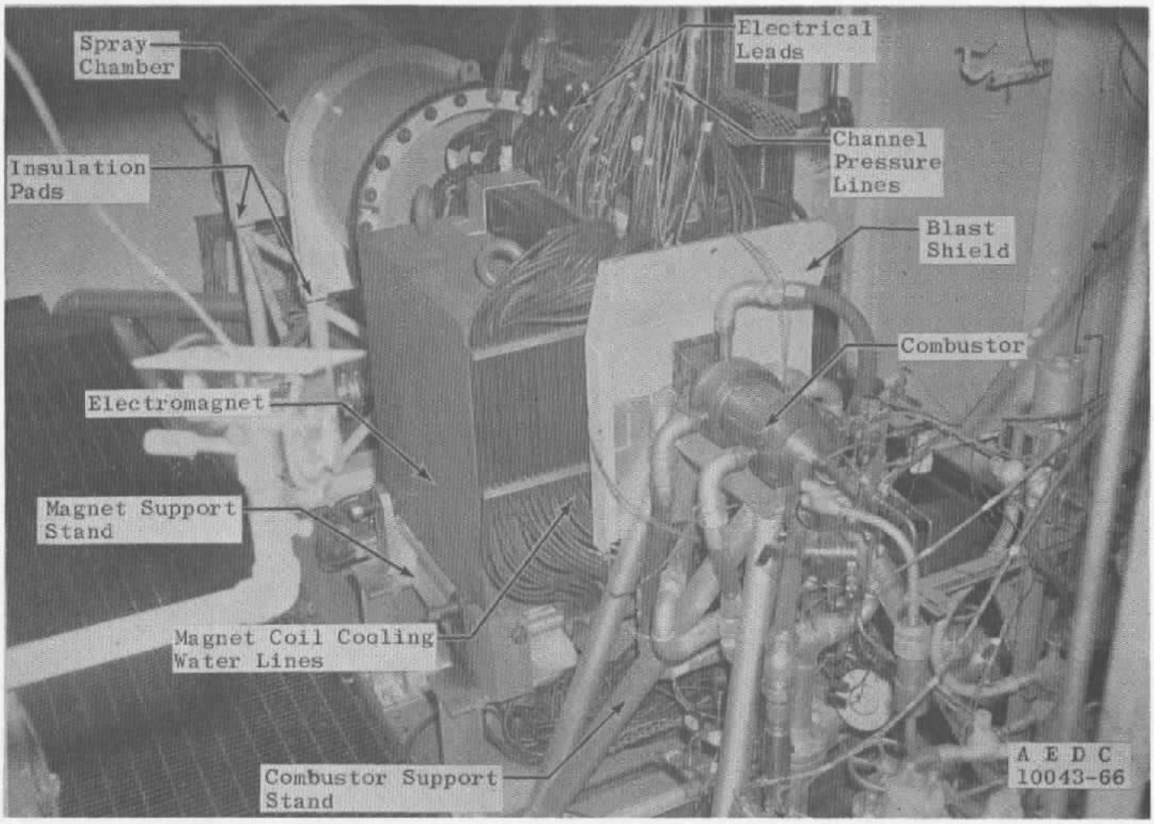
a. Photograph

Fig. 10 Igniter Assembly

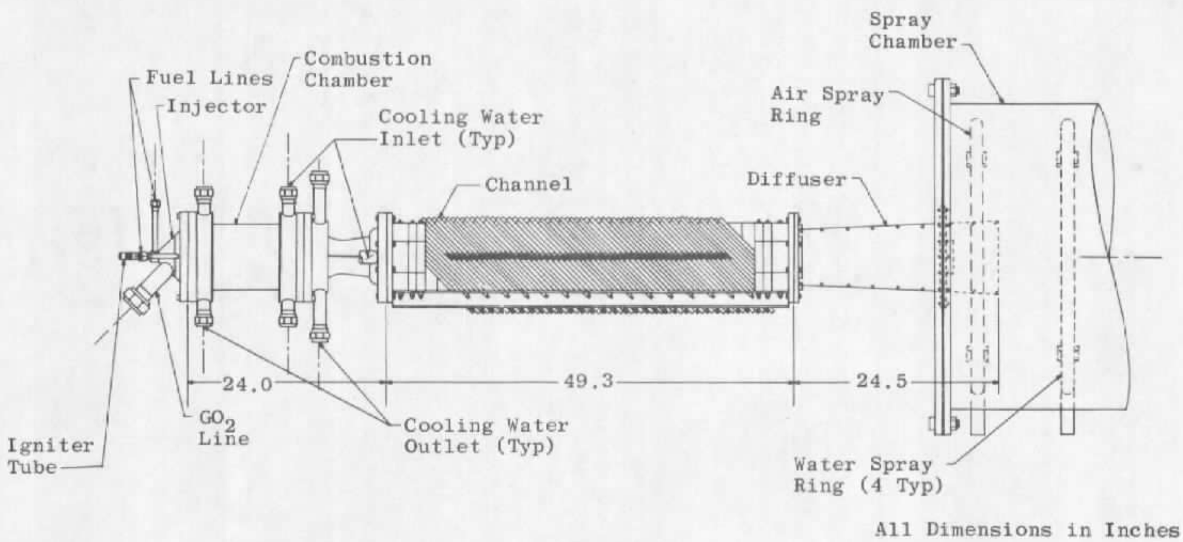


b. Schematic

Fig. 10 Concluded



a. Photograph



b. Schematic

Fig. 11 Installation of MHD Generator Assembly in Propulsion Research Area (R-2C-4)

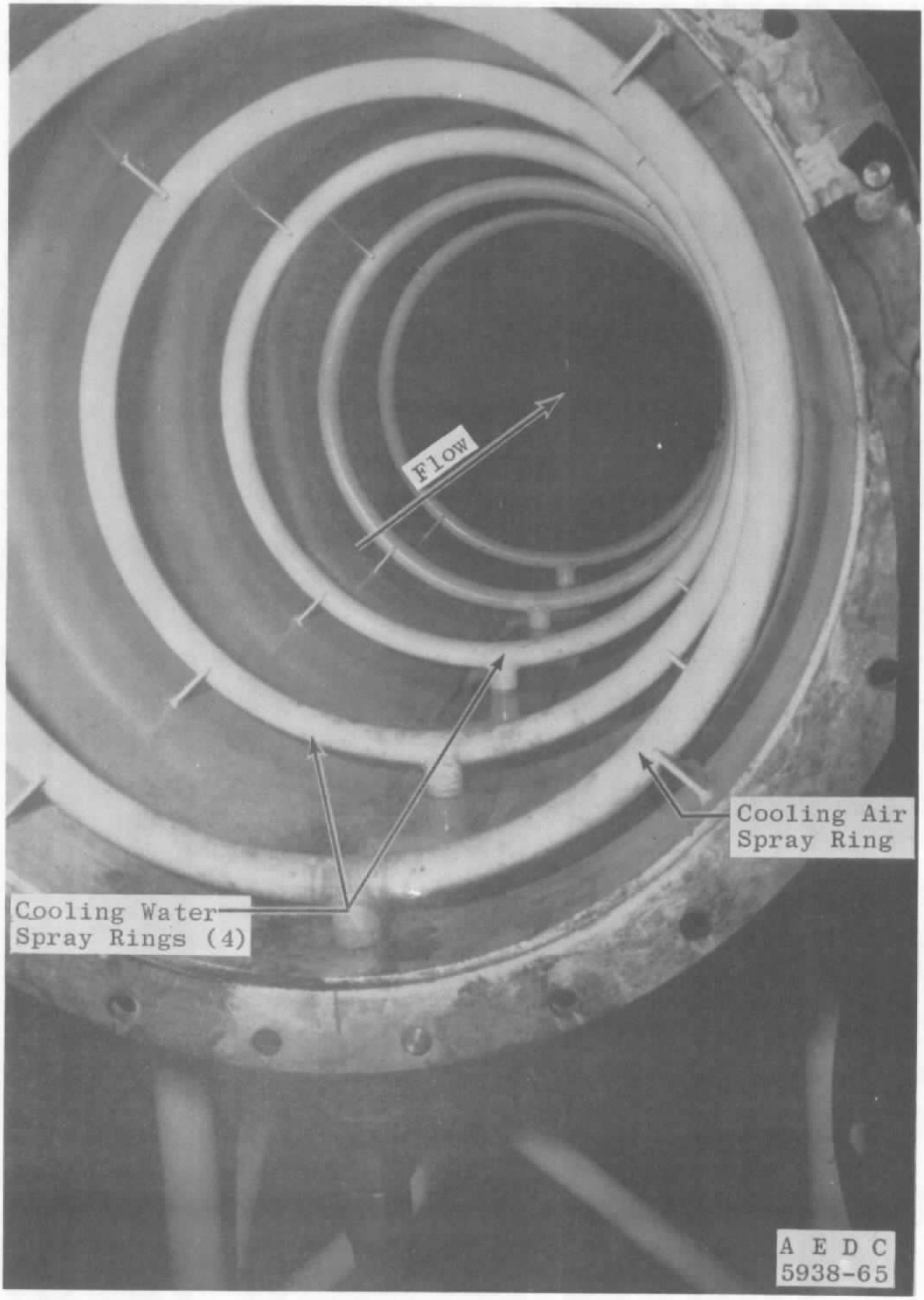
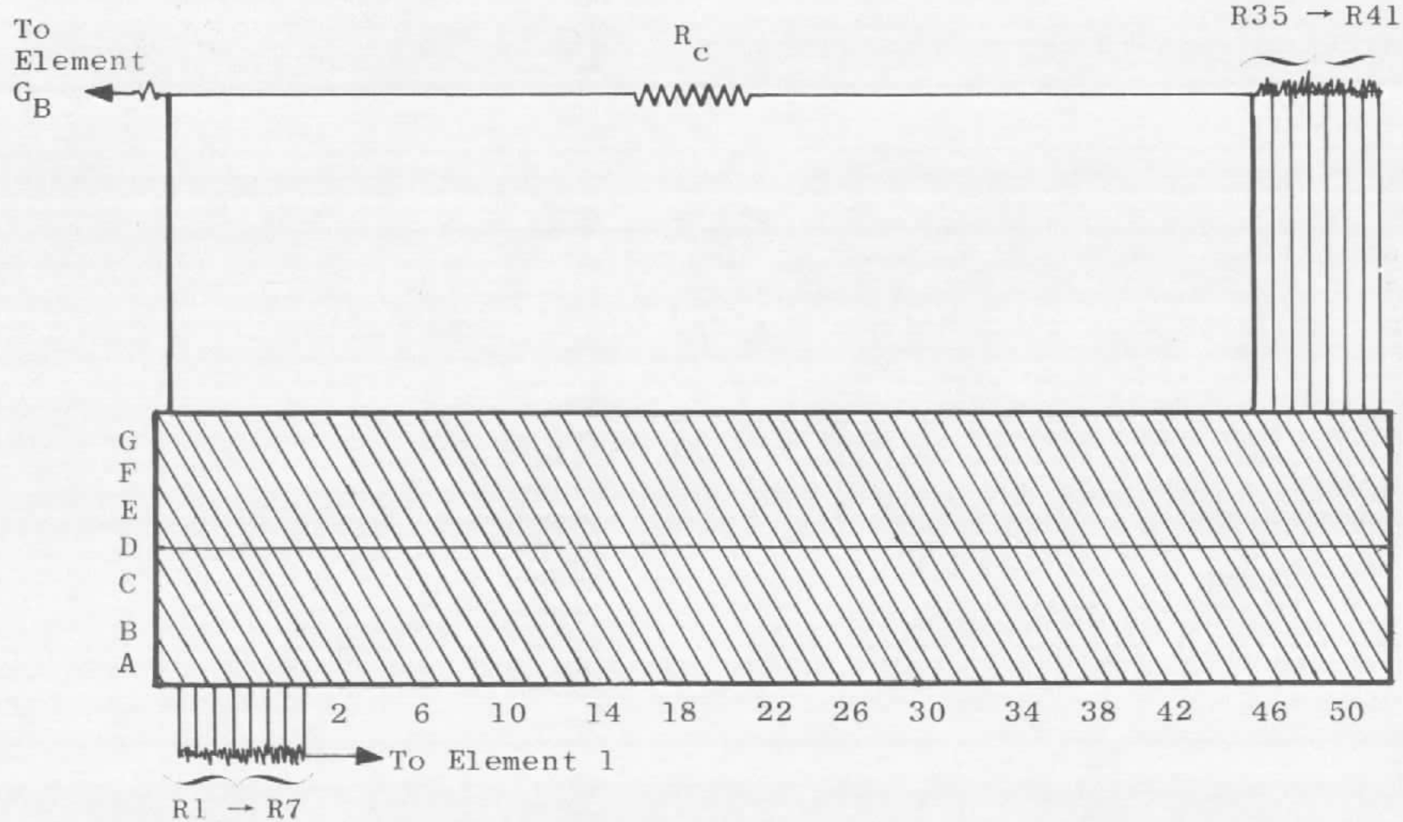
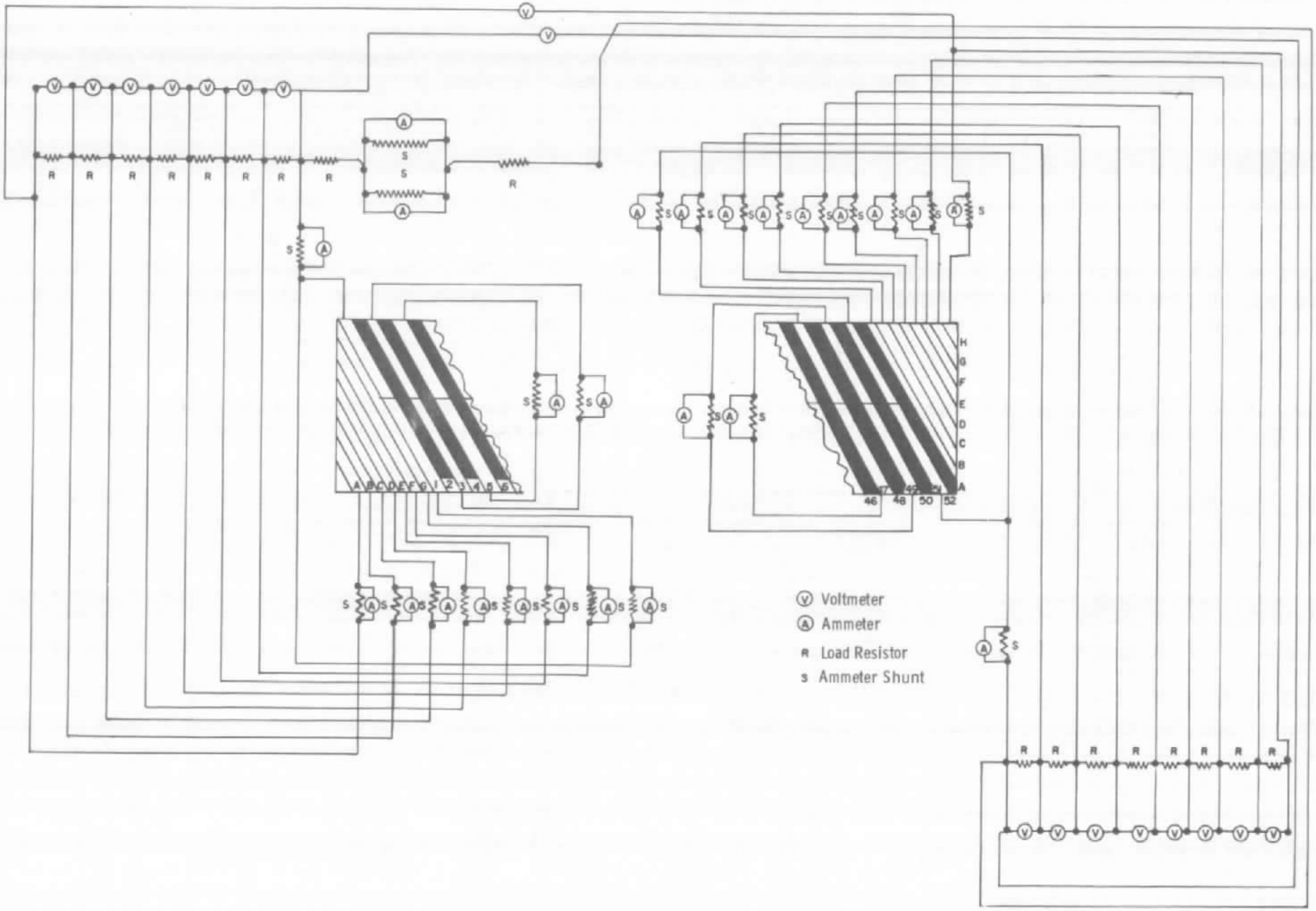


Fig. 12 Photograph of Spray Chamber



a. Without Instrumentation

Fig. 13 Schematic of Typical Electrical Circuit, 60-deg-Slant Channel



b. With Instrumentation

Fig. 13 Concluded

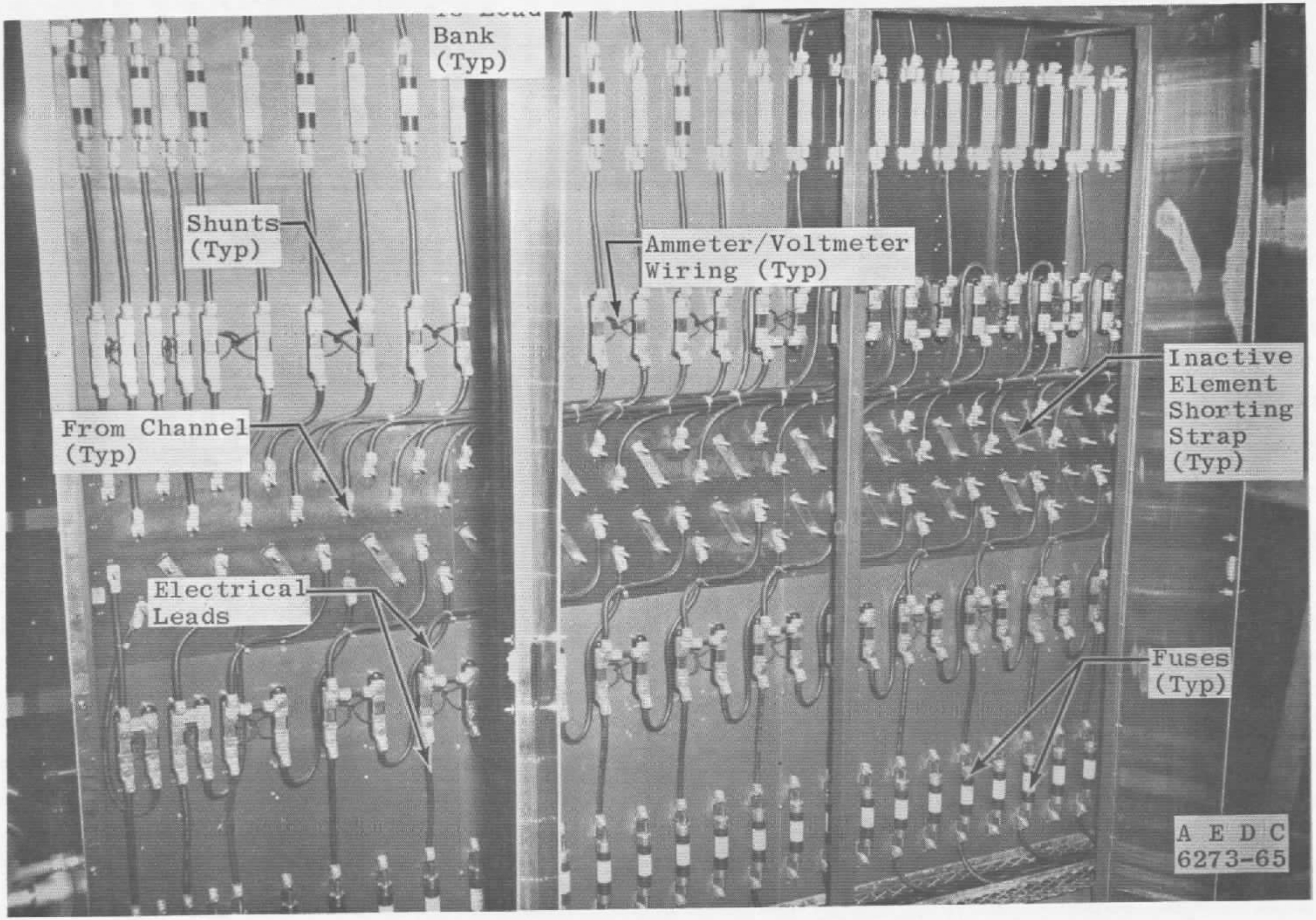


Fig. 14 Photograph of Shunt Panel

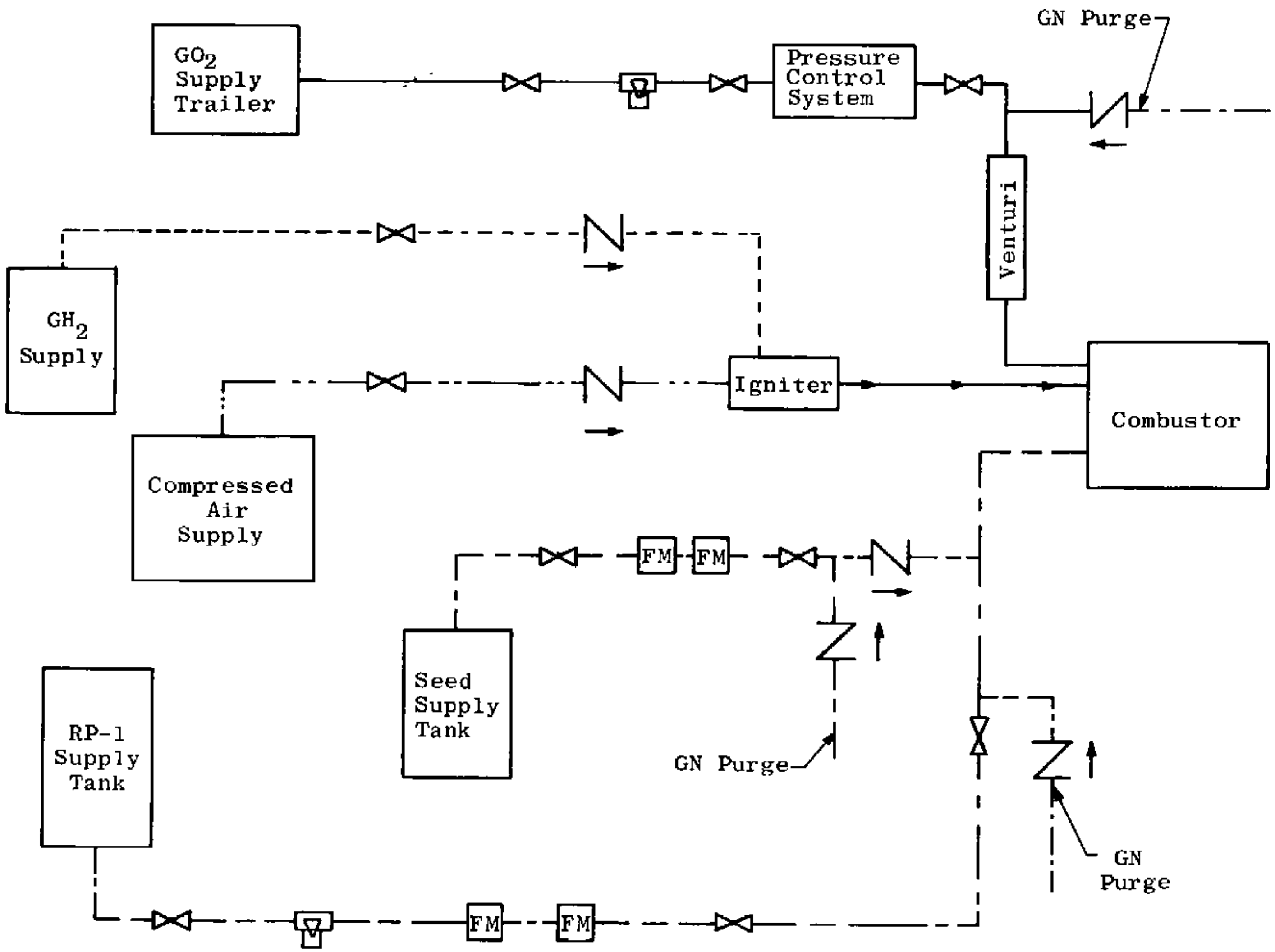


Fig. 15 Schematic of Propellant System

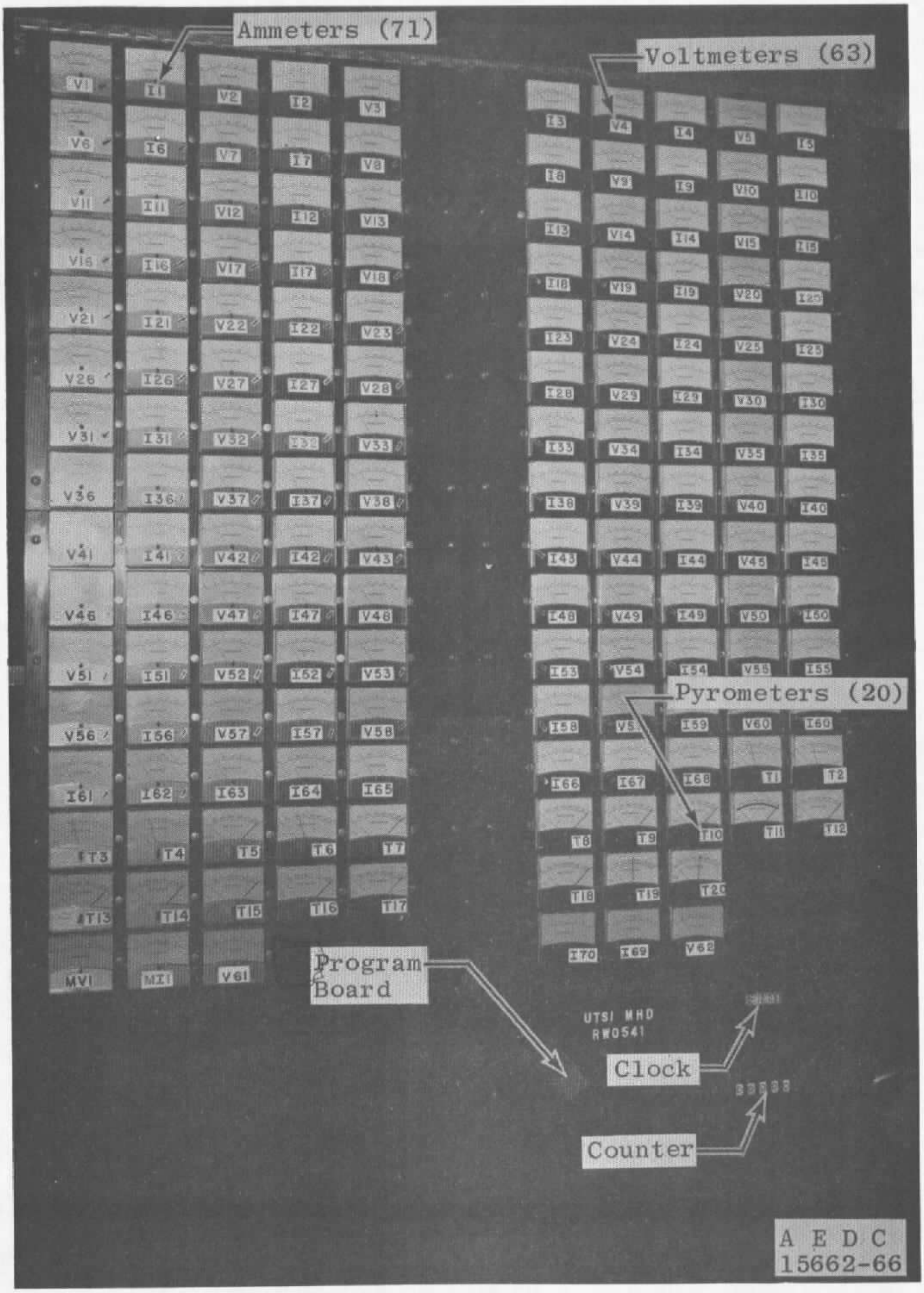


Fig. 16 Photograph of Meter Panel

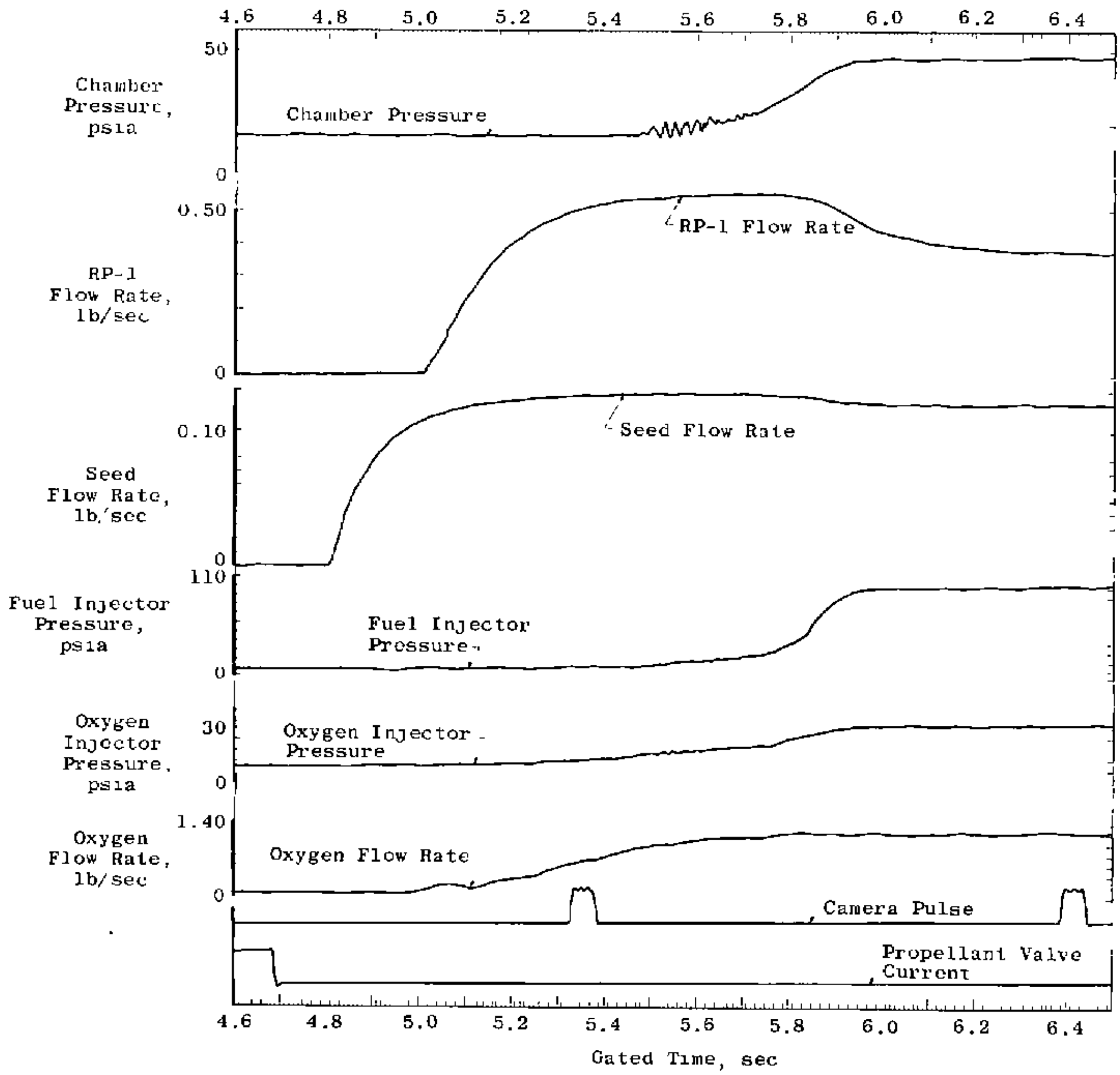


Fig. 17 Typical Engine Ignition Transient

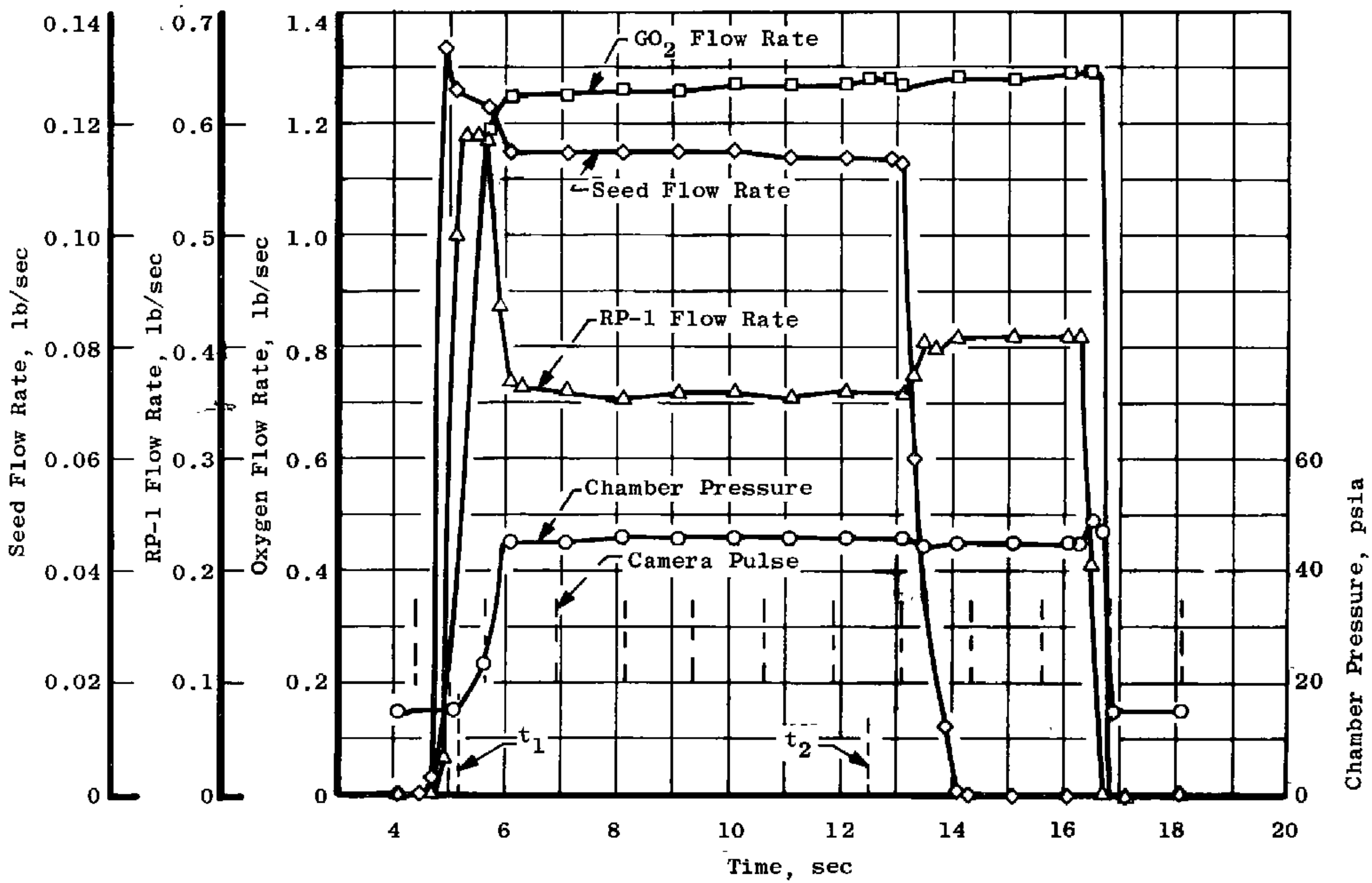


Fig. 18 Variation in Combustor Chamber Pressure and Seed and Propellant Flow Rates during a Typical Firing

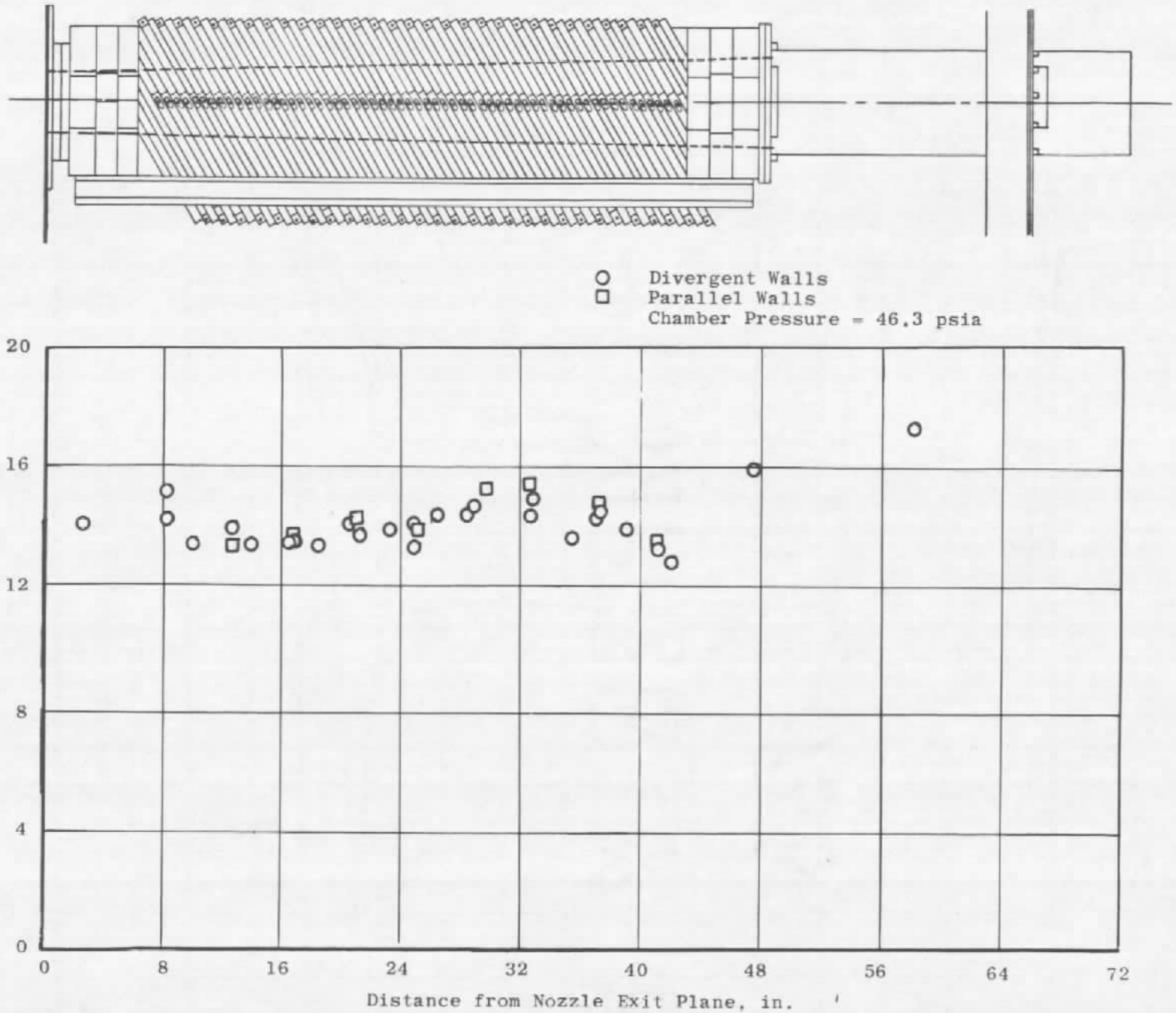


Fig. 19 Typical Values of Channel Pressures

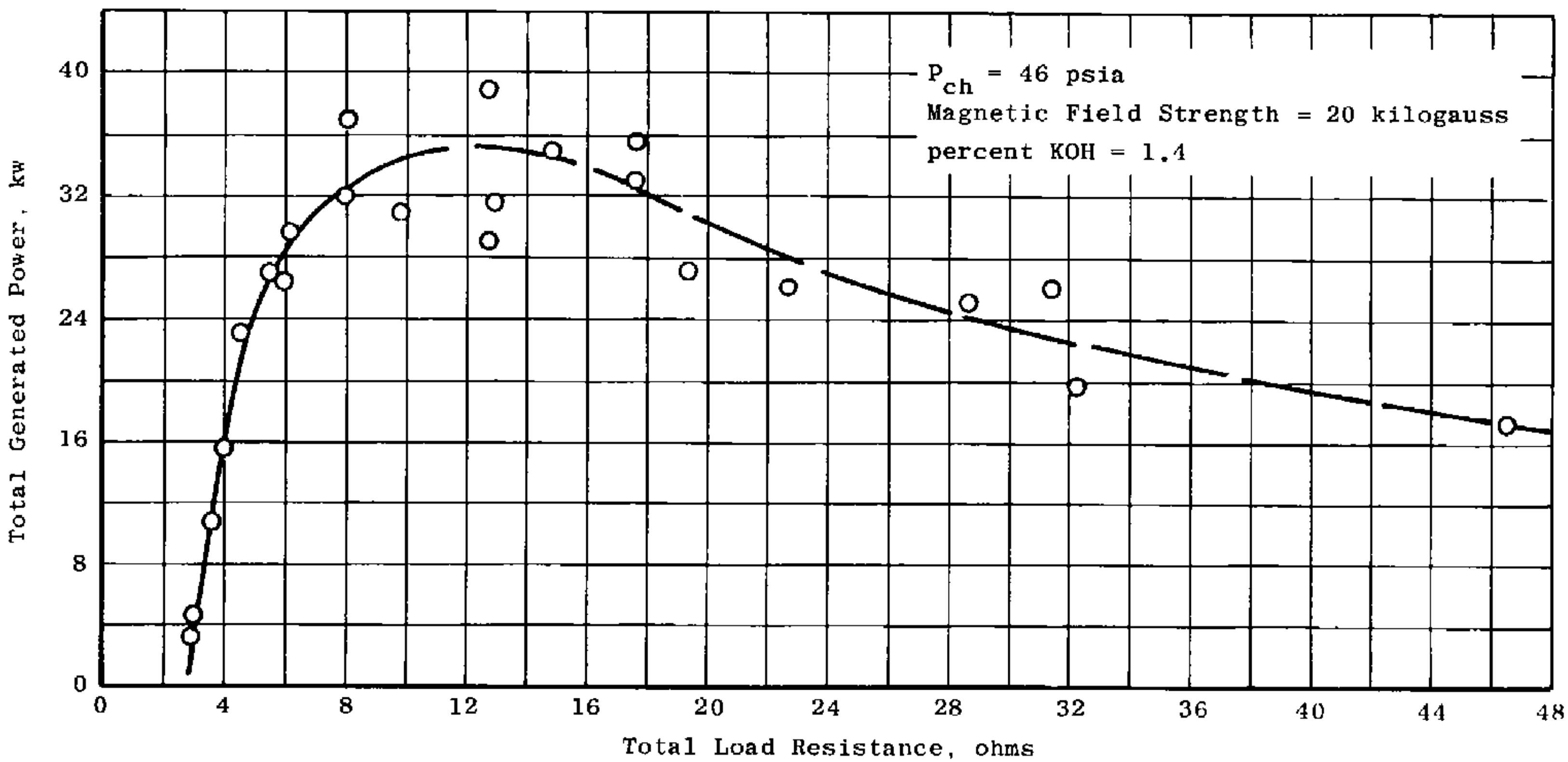


Fig. 20 Total Generated Power as a Function of Total Load Resistance

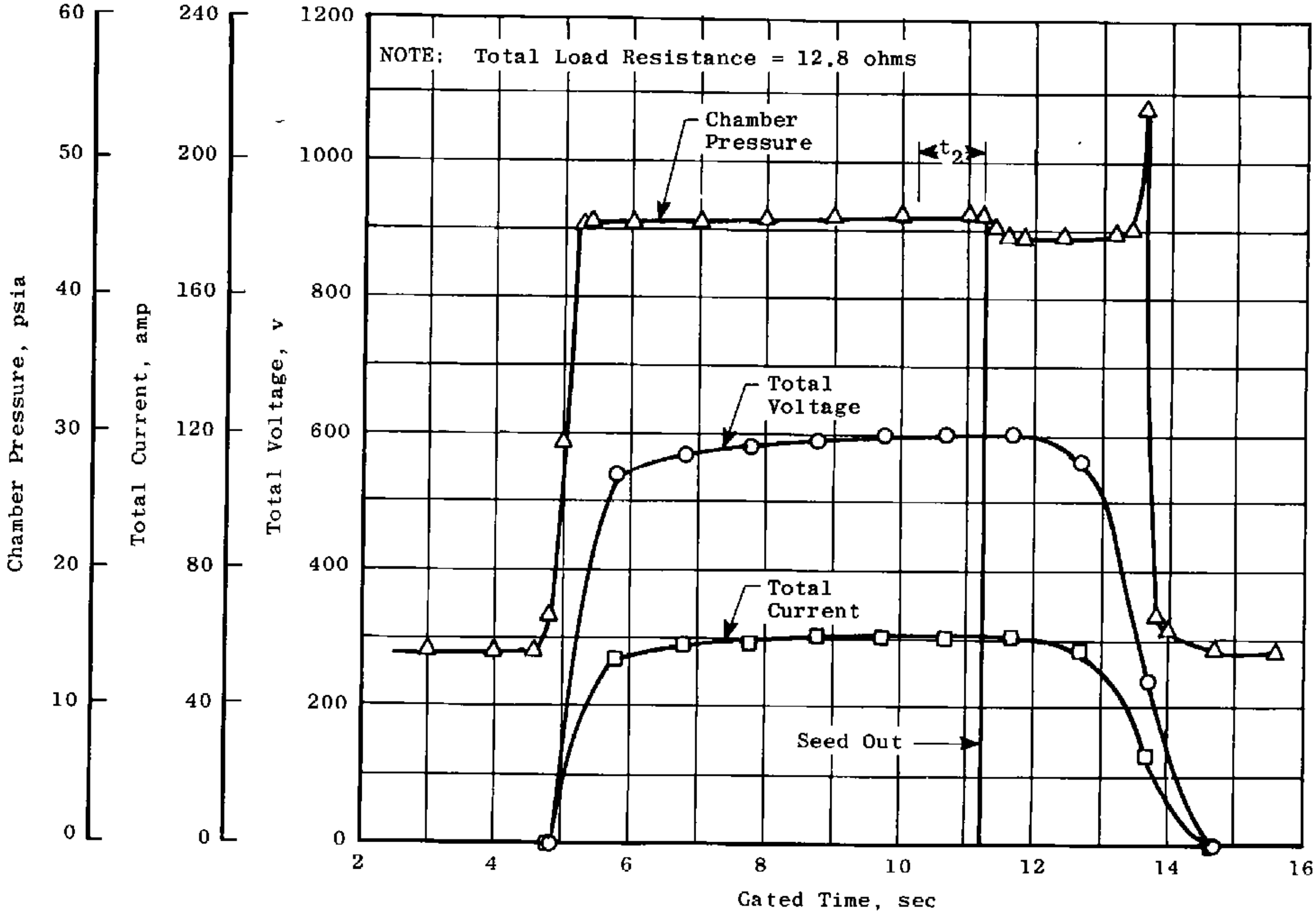


Fig. 21 Plot Showing Chamber Pressure, Total Voltage, and Total Current Variation with Time for a Typical Firing

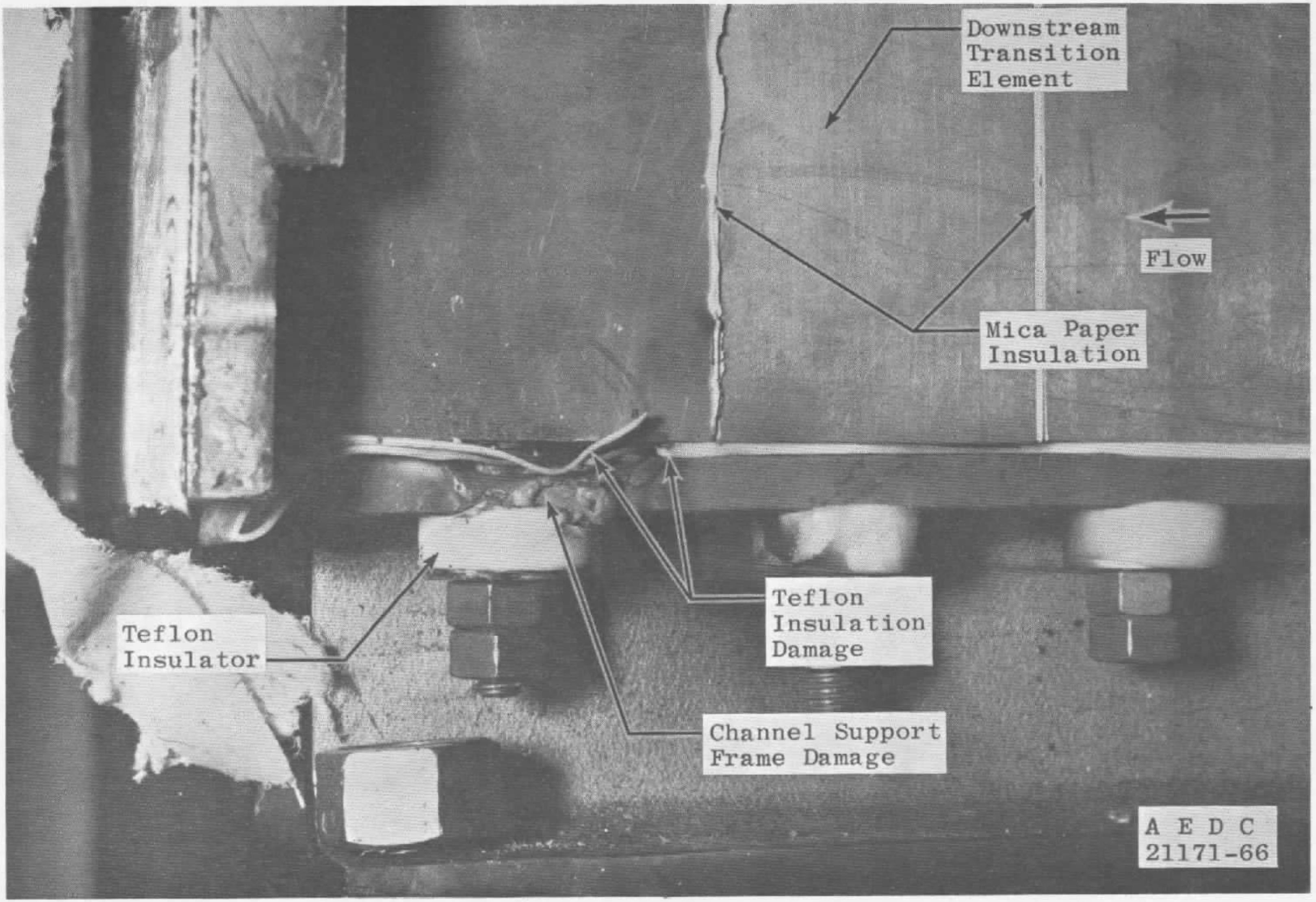


Fig. 22 Photograph Showing Typical Damage Caused by Arcing

TABLE I
INSTRUMENTATION

Parameter	Estimate of Measurement Uncertainty at Operating Level, percent*	Measuring Device	Range of Measuring Device	Recording Method
Chamber Pressure	±0.75	Bonded Strain-Gage Type Transducer	0-50 psia 0-100 psia	Millivolt-to-Frequency Converter onto Magnetic Tape
Venturi Upstream Pressure	±1	"	0-300 psia	"
RP-1 Flow Rate	±0.5	Turbine-Type Flowmeter	0-1.0 lb/sec	"
Seed Flow Rate	±0.5	"	0-0.16 lb/sec	"
Oxygen Flow Rate	±2	Venturi	---	"
Injector Pressures	±1	Bonded Strain-Gage-Type Transducer	0-200 psia 0-25 psia	"
Channel Pressure	±1	"	0-30 psia 0-50 psia	Low Level Multiplexed Analog-to-Digital Converter onto Magnetic Tape
Diffuser Pressure	±1	"	0-25 psia 0-50 psia	"
RP-1 Tank Pressure	±1	"	0-500 psia	"
Seed Tank Pressure	±1	"	0-500 psia	"
Channel Voltage	±1	Voltmeter	-20-100v	Timer Actuated Camera onto 70-mm Film
Magnet Voltage	±1	"	0-120v	"
Channel Current	±1	Ammeter	-20-100a	"
Magnet Current	±1	"	0-2000a	"
Time	---	Synchronous Timing Generator	---	Photographically Recording Galvanometer-Type Oscillograph

*Uncertainties are stated at an estimated two-standard-deviation level.

TABLE II
SUMMARY OF OPERATING CONDITIONS

Run Number*	Nominal Magnetic Field Strength, kilogauss	Nominal Chamber Pressure, psia	Measured Load Bank Resistance, ohms		Nominal Percent KOH of Total Flow Rate
			R_{center}	R_{total}	
43.5	20	46	4.11	6.21	1.4
43.6			2.46	4.56	
44.5			9.81	12.80	
44.8			14.7	17.7	
46.4			14.7	17.7	
46.6	15		28.3	31.3	
46.8	20		28.3	31.3	
46.10	20		14.7	17.7	
47.2	15		58.5	61.5	
47.3	20		58.5	61.5	
48.4	15		2.46	5.48	
48.5	20		2.46	5.48	
48.6	15		5.05	8.07	
48.7	20		5.05	8.07	
48.8			5.05	8.07	0.3
48.9			9.82	12.8	0.3
48.10	15		9.82	12.8	1.4
48.12	20		9.82	12.8	
48.13	15		14.8	17.8	
53.6	20		10.0	13.0	
53.8			11.9	14.9	
53.10			6.93	9.93	
53.13			5.10	8.10	
53.16			3.00	6.00	
54.5			2.05	5.05	
54.7			2.05	5.05	1.8
54.9			1.04	4.04	1.8
54.11			1.04	4.04	1.4
54.13			0.620	3.62	1.4
54.15			0.620	3.62	1.8
55.3			0	3.00	
55.5			6.93	9.93	
55.7			9.82	12.8	
55.9			14.7	17.7	
55.13			0	3.00	1.4
55.15			16.5	19.5	
55.17			19.7	22.7	
55.19			25.7	28.7	
56.5			0	3.00	
56.7			29.3	32.3	
56.9			43.5	46.5	
56.11			Open Circuit	---	

*Number before decimal denotes run sequence. Number after decimal denotes order of firings in each sequence.

TABLE III
SUMMARY OF COMBUSTOR PERFORMANCE

Run Number	t_1,* sec	t_2,** sec	Average Combustor Conditions at t_2			
			P_{ch}, psia	W_{O_2}, pps	W_{RP-1}, pps	W_{seed}, pps
43.5	4.7	11 0	46.3	1.272	0.359	0 118
43.6	4 9	10.8	46 3	1.282	0.360	0 118
44.5	4.7	7.6	45.7	1.261	0.358	0 117
44.8	4 7	6 8	45.1	1.241	0.361	0.117
46.4	5 3	9 7	46.7	1.283	0.365	0 116
46.6	5 3	10 1	46 7	1.278	0.363	0 116
46 8	5 3	10.1	46 7	1.258	0 365	0.116
46 10	5.3	10.7	46.7	1.283	0 365	0 116
47.2	5 5	10 7	45 6	1.255	0 360	0 116
47 3	5 5	8 3	45 8	1.254	0 361	0 117
48 4	4 7	10 4	46.7	1.295	0 347	0 116
48.5	4 7	11 2	46 4	1.291	0.341	0 116
48.6	4 7	10.6	46.0	1.265	0.343	0 116
48.7	4 7	10 6	45.9	1.264	0.341	0 116
48.8	4 7	11.0	45.8	1.266	0.418	0 022
48.9	4 7	11.0	46.1	1.273	0.423	0.024
48.10	4.7	10 6	46.5	1.270	0.345	0.115
48.12	4 7	10 6	46.0	1 267	0.347	0.116
48.13	4.7	10.4	46.0	1.266	0 345	0.115
53.6	4 7	10.8	46.5	1 287	0 365	0.115
53.8	4 7	11 0	46 5	1 280	0.366	0.115
53.10	4.7	11 0	46.3	1 281	0.363	0.115
53.13	4.7	10.8	46.0	1 275	0.364	0.116
53.16	4.7	10 8	46.0	1.275	0 364	0.116
54.5	4.7	11 0	45.7	1 262	0.367	0.112
54 7	4.7	10 4	45.7	1 263	0.332	0.152
54.9	4 7	10 6	45.8	1 270	0 331	0 152
54.11	4 7	10.4	45.7	1 270	0 365	0.112
54.13	4 5	10 6	45.6	1.271	0 365	0 113
54.15	4 7	10.8	45.5	1.269	0.329	0.152
55.3	4 7	10.4	45 8	1.264	0.330	0.153
55 5	4.7	11.0	45.7	1 269	0 328	0 153
55.7	4.7	10.8	45 8	1 270	0.330	0 153
55.9	4.7	10.2	46 1	1 271	0.343	0.152
55.13	4.7	10.6	45.8	1 270	0.363	0.113
55.15	4 7	11.2	45 6	1 263	0 361	0 113
55.17	4.7	10.4	45 6	1 266	0 361	0.112
55.19	4.7	11.2	45 6	1 265	0.362	0 112
56.5	4.7	10.8	45.7	1 295	0.361	0 113
56.7	4.7	10.0	46 0	1.296	0.363	0 113
56.9	4.7	10.4	45.9	1.297	0.362	0 113
56.11	4.7	10.4	46 0	1.299	0.359	0.117

*Initiation of Chamber Pressure Increase
**Midpoint of 1-sec Time Interval prior to Seed Flow Shutoff

TABLE IV
SUMMARY OF MEASURED LOAD BANK RESISTANCES

Run Number	Measured Resistance, ohms														
	R1	R2	R3	R4	R5	R6	R7	R_c	R35	R36	R37	R38	R39	R40	R41
43.5	0.126	0.136	0.146	0.156	0.178	0.195	0.227	4.11	0.174	0.155	0.176	0.129	0.118	0.109	0.070
43.6								2.46							
44.5	0.178	0.203	0.201	0.236	0.263	0.293	0.341	9.81	0.264	0.227	0.201	0.195	0.172	0.153	0.097
44.8								14.7							
46.4								14.7							
46.6								28.3							
46.8								28.3							
46.10								14.7							
47.2								58.5							
47.3								58.5							
48.4								2.46							
48.5								2.46							
48.6								5.05							
48.7								5.05							
48.8								5.05							
48.9								9.82							
48.10								9.82							
48.12								9.82							
48.13								14.8							

TABLE IV (Concluded)

Run Number	Measured Resistance, ohms														
	R1	R2	R3	R4	R5	R6	R7	R_c	R35	R36	R37	R38	R39	R40	R41
53.6	0.178	0.200	0.199	0.233	0.264	0.290	0.338	10.0	0.264	0.226	0.195	0.196	0.171	0.153	0.095
53.8								11.9							
53.10								6.93							
53.13								5.10							
53.16								3.00							
54.5								2.05							
54.7								2.05							
54.9								1.04							
54.11								1.04							
54.13								0.620							
54.15								0.620							
55.3								0							
55.5								6.93							
55.7								9.82							
55.9								14.7							
55.13								0							
55.15								16.5							
55.17								19.7							
55.19								25.7							
56.5								0							
56.7								29.3							
56.9								43.5							
56.11								Open Circuit							

TABLE V
SUMMARY OF CHANNEL ELECTRICAL MEASUREMENTS
a. Channel-to-Load Bank

Run Number	Magnet Field Strength, kilogauss	Magnet Current, amp	Time, T_2, sec	R_c Current, I59, amp	Current, Channel-to-Load Bank, amp															
					Element A_B I2	Element B_B I4	Element C_B I6	Element D_B I8	Element E_B I10	Element F_B I12	Element G_B I14	Element 1 I18	Element A_T I1	Element B_T I3	Element C_T I5	Element D_T I7	Element E_T I9	Element F_T I11	Element G_T I13	Element H_T I15
43.5	20	1200	11.0	80	-4	-14	-9	-1	-8	-10	-12	-17	21	12	13	9	8	8	4	4
43.6			10.8	86	-4	-14	-8	-7	-8	-10	-13	-22	24	14	12	9	8	8	6	4
44.5			7.6	54	-2	-6	-6	-3	-7	-10	-10	-9	15	9	10	6	6	2	3	2
44.8			6.8	27	-2	0	-5	-5	10	-9	-10	-6	4	6	4	4	4	2	0	0
46.4			9.7	46	-2	-10	-7	-6	-4	-8	-8	0	16	8	8	7	6	4	1	2
46.6	15	650	10.1	22	-1	-6	-4	-4	-4	-6	-5	8	6	4	3	3	3	2	0	2
46.8	20	1200	10.1	30	-4	-10	-8	-3	-4	-7	-5	12	8	6	3	5	4	3	0	2
46.10	20	1200	10.7	46	-2	-10	-8	-5	-6	-8	-4	-2	14	8	7	6	6	4	1	2
47.2	15	650	10.7	11	-1	-4	-2	3	-2	-6	-4	12	3	2	2	2	1	0	0	2
47.3	20	1200	8.3	6	2	0	0	6	-4	-8	-8	6	6	6	3	3	2	0	0	-13
48.4	15	650	10.4	59	0	7	-4	-5	-4	-10	-10	-18	17	9	10	8	7	4	2	3
48.5	20	1200	11.2	93	-2	11	-7	-8	-7	-11	-15	-31	36	13	14	12	8	6	3	2
48.6	15	650	10.6	49	0	-5	-3	4	-4	-10	-10	-14	14	10	8	7	6	4	2	2
48.7	20	1200	10.6	80	-2	-12	-7	-4	-7	-12	-14	-20	28	13	12	10	8	6	3	3
48.8			11.0	57	-2	-8	-6	-5	-4	-6	-10	-16	12	8	8	6	6	6	6	6
48.9			11.0	45	-2	-6	-5	-4	-4	-6	-8	-8	9	6	6	6	6	5	4	4
48.10	15	650	10.6	16	-1	-8	-5	-4	-6	-8	-8	-7	13	8	6	6	6	4	2	4
48.12	20	1200	10.6	61	-2	-12	-8	-2	-6	-10	-10	-8	20	10	9	8	6	5	2	4
48.13	15	650	10.4	34	-1	-6	-4	-3	-4	-8	-8	0	8	7	5	4	4	3	1	3
53.6	20	1200	10.8	55	-3	-10	-8	-3	-5	-6	-10	-10	16	8	6	7	6	6	3	2
53.8	20	1200	11.0	52	-4	-10	-8	-3	-5	-7	-9	-6	15	8	5	8	6	6	2	2

TABLE V
a. Concluded

Run Number	Magnet Field Strength, kilogauss	Magnet Current, amp	Time, T_2, sec	R_c Current, I69, amp	Current, Channel-to-Load Bank, amp															
					Element A_B I2	Element B_B I4	Element C_B I6	Element D_B I8	Element E_B I10	Element F_B I12	Element G_B I14	Element 1 I18	Element A_T I1	Element B_T I3	Element C_T I5	Element D_T I7	Element E_T I9	Element F_T I11	Element G_T I13	Element H_T I15
53 10	20	1200	11 0	64	-4	-10	-7	-2	-6	-12	-12	-13	18	10	8	8	7	7	4	2
53.13			10.8	74	-4	-10	-8	-4	-6	- 8	-12	-20	22	11	9	9	8	7	4	2
53.16			10.8	82	-4	-10	-7	-3	-7	-10	-14	-24	25	13	10	10	8	8	3	2
54.5			11.0	75	-2	- 9	-7	-3	-7	-12	-14	-25	22	12	11	9	9	8	5	3
54.7			10.4	88	-3	-10	-8	-4	-7	-12	-16	-27	28	14	12	10	9	8	5	2
54.9			10.6	95	-4	-10	-8	-5	-7	-12	-16	-32	31	15	12	11	9	8	6	2
54.11			10.4	95	-4	-10	-8	-4	-7	-12	-16	-32	29	15	13	11	10	8	6	2
54.13			10.6	94	-4	-10	-8	-4	-7	-12	-16	-32	29	15	12	11	10	9	4	2
54.15			10.8	102	-4	-10	-8	-5	-7	-12	-17	-36	35	16	13	12	10	9	6	2
55 3			10.4	93	-3	- 9	-7	-7	-5	-12	-14	-33	32	14	10	11	8	7	5	3
55.5			11.0	60	-2	- 8	-6	-3	-5	-11	-10	-12	19	9	8	7	6	5	0	2
55 7			10 8	52	-3	- 8	-6	-4	-4	-10	- 8	- 7	14	9	6	7	6	5	2	2
55 9			10.2	41	-2	- 7	-5	-2	-4	-10	- 8	- 1	10	8	5	6	5	4	2	2
55.13			10.6	101	-4	-10	-8	-6	-7	-12	-17	-37	34	14	14	11	9	8	4	3
55 15			11.2	41	-2	- 8	-6	-2	-4	- 7	- 8	0	10	7	4	6	6	4	2	2
55 17			10 4	36	-2	- 8	-6	-2	-4	- 6	- 7	0	8	6	4	6	6	4	2	2
55.19			11.2	30	-4	- 8	-7	-2	-4	- 4	- 7	6	6	6	2	5	6	4	2	2
56 5			10.8	77	-2	- 7	-5	-6	-6	-12	-14	-25	22	11	11	11	8	6	6	2
56.7			10.0	28	-2	- 6	-4	-1	-3	- 8	- 6	6	6	4	2	4	4	3	0	2
56.9			--	19	-2	- 7	-5	-2	-3	- 6	- 4	11	6	4	0	4	4	3	1	2
56.11			10 4	0	-2	- 7	-4	4	-3	- 7	- 4	20	1	3	-2	2	2	1	0	3

TABLE V

b. Element Top-To-Element Bottom

Run Number	Time, t2, sec	Current, Element Top-to-Element Bottom, amp																									
		Element 1 I17	Element 3 I19	Element 5 I21	Element 7 I23	Element 9 I25	Element 11 I27	Element 13 I29	Element 15 I31	Element 17 I33	Element 19 I65	Element 21 I67	Element 23 I36	Element 25 I38	Element 27 I40	Element 29 I42	Element 31 I44	Element 33 I46	Element 35 I48	Element 37 I50	Element 39 I52	Element 41 I54	Element 43 I56	Element 45 I58	Element 47 I60	Element 49 I62	Element 51 I64
43.5	11.0	18	10	10	14	13	12	13	11	12	13	13	11	13	12	12	12	11	12	11	12	12	10	10	11	10	6
43.6	10.8	21	9	9	13	12	11	12	10	12	12	12	11	12	12	11	11	10	11	11	12	12	10	10	10	8	5
44.5	7.6	13	10	10	13	12	11	12	10	12	14	12	10	12	11	11	11	10	11	11	11	10	10	10	10	8	6
44.8	6.8	10	10	10	12	12	10	10	10	10	10	10	10	11	10	10	10	8	6	12	12	10	10	10	10	9	7
46.4	9.7	12	11	10	12	13	12	14	12	13	12	13	12	14	12	14	13	10	12	13	13	12	10	11	10	9	6
46.6	10.1	6	10	8	10	10	10	10	8	10	10	10	8	10	10	10	10	10	10	10	10	10	9	10	10	8	7
46.8	10.1	2	11	10	12	11	12	13	12	14	22	13	8	10	11	12	14	10	13	13	13	13	10	12	12	10	8
46.10	10.7	13	12	10	13	10	10	13	10	12	13	12	10	11	12	14	13	10	12	12	12	12	12	11	12	9	6
47.2	10.7	4	9	7	10	9	9	9	7	8	9	9	8	8	9	9	9	9	8	9	9	9	8	8	-	8	6
47.3	8.3	8	10	10	12	12	12	12	10	12	12	12	10	11	12	11	11	10	10	11	11	10	10	9	--	8	6
48.4	10.4	18	8	6	9	8	8	9	8	9	4	8	7	9	8	9	8	8	8	9	9	9	8	7	--	7	4
48.5	11.2	29	10	10	14	13	13	13	12	14	13	12	12	14	12	14	12	11	10	13	12	12	10	10	--	8	4
48.6	10.6	15	8	8	10	10	10	10	8	10	4	10	9	10	10	10	10	9	8	10	10	9	8	8	--	8	5
48.7	10.6	22	11	12	14	13	14	14	12	14	14	14	13	14	14	14	13	12	11	14	12	12	10	10	--	8	5
48.8	11.0	13	6	4	7	8	7	8	6	7	4	8	6	8	8	7	8	7	7	7	7	7	6	6	--	6	3
48.9	11.0	10	5	4	6	8	7	7	6	6	4	7	6	7	7	6	7	6	7	7	7	7	6	6	--	6	4
48.10	10.5	12	10	9	11	10	11	11	10	11	4	10	10	11	11	11	11	10	10	10	10	11	10	10	-	10	6
48.12	10.6	16	14	12	14	14	14	16	14	14	14	14	14	15	14	15	13	11	13	14	14	13	11	11	--	10	6
48.13	10.4	9	9	8	10	10	10	10	9	10	4	10	9	10	10	10	10	10	9	10	10	10	8	8	--	8	6
53.6	10.8	14	11	10	11	14	12	14	10	13	12	12	12	14	11	14	12	10	10	13	14	12	10	12	11	8	6
53.8	11.0	14	10	10	12	14	13	14	12	13	13	13	12	14	12	13	12	10	12	13	12	12	10	11	11	8	6

TABLE V
b. Concluded

Run Number	Time, t2, sec	Element 1 I17	Element 3 I19	Element 5 I21	Element 7 I23	Element 9 I25	Element 11 I27	Element 13 I29	Element 15 I31	Element 17 I33	Element 19 I65	Element 21 I67	Element 23 I36	Element 25 I38	Element 27 I40	Element 29 I42	Element 31 I44	Element 33 I46	Element 35 I48	Element 37 I50	Element 39 I52	Element 41 I54	Element 43 I56	Element 45 I58	Element 47 I60	Element 49 I62	Element 61 I64
		Current, Element Top-to-Element Bottom, amp																									
53.10	11.0	16	10	9	10	12	12	13	11	12	13	12	10	12	12	12	12	10	10	12	12	11	10	10	10	8	6
53.13	10.8	19	10	9	10	12	12	14	10	12	12	12	11	12	12	12	12	10	11	12	12	12	10	10	10	8	6
53.16	10 8	23	9	8	10	12	12	12	10	12	12	12	10	12	12	12	11	10	10	12	12	11	10	10	10	8	5
54.5	11.0	22	7	6	9	10	9	10	8	10	11	10	9	10	10	10	10	10	9	10	10	10	9	9	10	8	5
54.7	10.4	26	8	8	11	12	11	13	10	12	13	12	10	12	12	12	11	10	10	11	12	11	10	10	10	8	5
54.9	10.6	29	8	8	11	11	10	12	10	12	12	11	10	12	12	12	12	10	10	11	12	11	10	10	10	8	5
54.11	10.4	28	8	8	10	11	10	12	10	11	11	10	10	12	11	12	11	10	10	11	11	11	10	10	10	8	5
54.13	10.6	28	7	7	10	10	10	12	10	10	11	10	10	11	11	12	10	10	10	11	11	11	10	9	10	8	4
54 15	10.8	30	9	8	10	12	10	13	10	12	12	11	11	12	12	12	12	10	11	12	12	12	10	10	10	8	4
55.3	10.4	27	7	7	9	9	8	11	7	9	9	9	8	11	8	9	--	8	10	9	10	9	8	9	9	7	4
55.5	11.0	15	9	8	10	11	11	13	9	11	12	11	10	12	11	12	11	10	10	11	12	10	10	10	10	8	5
55.7	10.8	14	10	9	11	12	11	13	10	12	13	12	10	12	12	12	12	10	10	11	12	11	10	10	10	8	7
55.9	10.2	10	10	8	10	11	11	13	9	12	12	12	10	12	11	11	11	10	--	11	11	10	10	10	10	8	6
55.13	10.6	28	7	7	9	10	9	12	9	10	10	10	10	11	10	11	11	9	10	10	10	10	9	9	9	8	4
55.15	11 2	10	10	9	10	12	11	12	10	12	12	12	10	12	11	12	12	10	10	12	11	10	9	10	10	8	6
55.17	10.4	8	8	8	10	10	10	12	8	11	10	10	10	12	10	12	11	10	10	12	10	10	9	10	10	8	6
55.19	11.2	7	10	8	12	12	10	12	10	12	12	11	10	12	10	12	12	10	11	12	12	12	10	11	11	8	8
56.5	10.8	22	5	5	7	8	7	9	6	8	8	8	7	9	8	8	8	7	8	8	9	8	8	8	8	6	3
56.7	10.0	5	8	8	9	10	10	10	8	10	11	10	9	11	10	10	10	10	10	10	10	10	9	9	10	8	6
56.9	10.4	4	8	8	10	11	10	12	9	11	12	12	10	11	11	11	10	10	10	10	10	10	10	10	10	8	6
56 11	10.4	2	8	8	10	11	10	11	10	12	13	12	10	11	11	11	10	10	10	11	11	10	10	10	10	8	7

TABLE V
c. Load Bank Voltages

Run Number	Time, t_2, sec	Load Bank Voltage, v: R1 (Element A_B → Element B_B, V2)	R2 (Element B_B → Element C_B, V4)	R3 (Element C_B → Element D_B, V6)	R4 (Element D_B → Element E_B, V8)	R5 (Element E_B → Element F_B, V10)	R6 (Element F_B → Element G_B, V12)	R7 (Element G_B → Element 1, V14)	R_c (Element 1 → Element A_T, V62)	R35 (Element A_T → Element B_T, V1)	R36 (Element B_T → Element C_T, V3)	R37 (Element C_T → Element D_T, V5)	R38 (Element D_T → Element E_T, V7)	R39 (Element E_T → Element F_T, V9)	R40 (Element F_T → Element G_T, V11)	R41 (Element G_T → Element H_T, V13)
43.5	11.0	0	2	4	5	8	10	15	330	8	7	6	2	2	1	0
43.6	10.8	0	2	4	5	8	10	16	220	9	6	6	2	2	1	0
44.5	7.6	0	1	3	4	7	10	16	520	0	6	4	2	2	1	0
44.8	6.8	0	0	2	4	0	4	8	420	0	4	2	0	0	0	0
46.4	9.7	0	2	4	6	10	12	16	700	0	5	4	1	2	0	0
46.6	10.1	0	2	2	4	6	8	11	610	0	2	2	0	1	0	0
46.8	10.1	0	3	4	6	8	12	16	820	0	3	3	0	0	0	0
46.10	10.7	0	3	4	6	10	12	16	670	0	5	3	2	1	0	0
47.2	10.7	0	1	2	2	4	6	9	640	0	1	1	0	0	0	0
47.3	8.3	0	0	0	-2	0	2	6	360	0	-2	-2	-3	-2	-2	-1
48.4	10.4	0	2	2	4	6	10	14	150	0	8	5	2	2	0	0
48.5	11.2	0	3	4	7	10	14	22	240	0	10	6	3	2	0	0
48.6	10.6	0	2	2	4	6	9	14	260	0	6	4	2	2	0	0
48.7	10.6	0	3	4	6	10	14	21	410	0	9	6	3	2	0	0
48.8	11.0	0	2	3	5	8	10	14	300	0	8	6	4	3	2	0
48.9	11.0	0	2	3	4	6	8	13	440	0	6	5	3	2	2	0
48.10	10.6	0	2	3	4	7	10	14	460	0	6	4	2	2	0	0
48.12	10.6	0	3	4	6	9	13	19	600	0	7	4	2	2	0	0
48.13	10.4	0	2	2	3	5	8	12	500	0	4	3	0	1	0	0
53.6	10.8	0	3	4	6	7	11	16	540	10	6	5	2	2	1	0
53.8	11.0	0	3	4	6	8	12	16	620	9	6	5	2	2	1	0

TABLE V
c. Concluded

Run Number	Time, t2, sec	Load Bank Voltage, v														
		R1	R2	R3	R4	R5	R6	R7	R_c	R35	R36	R37	R38	R39	R40	R41
		Element A_B Element B_B V2	Element B_B Element C_B V4	Element C_B Element D_B V6	Element D_B Element E_B V8	Element E_B Element F_B V10	Element F_B Element G_B V12	Element G_B Element 1 V14	Element 1 Element A_T V62	Element A_T Element B_T V1	Element B_T Element C_T V3	Element C_T Element D_T V5	Element D_T Element E_T V7	Element E_T Element F_T V9	Element F_T Element G_T V11	Element G_T Element H_T V13
53 10	11 0	0	3	4	6	8	12	18	440	12	8	6	3	2	1	0
53.13	10.8	0	4	4	6	9	13	19	380	13	9	6	4	3	1	0
53 16	10.8	0	3	4	6	9	14	20	260	15	10	7	4	3	1	0
54 5	11.0	0	2	4	6	8	12	20	160	14	10	7	4	3	1	0
54.7	10.4	0	3	4	6	10	14	22	195	16	10	7	4	3	1	0
54.9	10.6	0	3	4	7	10	14	22	105	16	11	8	4	3	1	0
54.11	10 4	0	3	4	7	10	15	22	105	17	11	8	4	3	2	0
54 13	10 6	0	3	4	6	10	14	22	60	17	11	8	4	3	1	0
54.15	10 8	0	3	5	7	10	16	23	70	18	12	8	5	3	2	0
55.3	10.4	0	3	4	7	8	14	21	0	5	10	7	4	3	1	0
55.5	11.0	0	2	3	4	7	12	16	420	7	7	5	2	2	0	0
55 7	10.8	0	2	3	6	7	9	17	520	6	6	4	2	2	0	0
55.9	10.2	0	2	3	4	7	10	14	600	4	4	4	2	1	0	0
55.13	10.6	0	3	4	7	10	15	22	0	11	12	8	5	4	1	0
55.15	11.2	0	2	4	5	7	10	14	650	5	5	4	2	2	0	0
55.17	10.4	0	2	4	4	6	8	12	700	4	4	4	2	2	0	0
55.19	11 2	0	3	4	6	7	10	14	840	4	4	4	2	2	0	0
56.5	10 8	0	2	3	5	8	12	18	0	11	10	7	4	3	1	0
56.7	10 0	0	2	3	3	5	8	12	740	4	3	2	1	1	0	0
56.9		0	2	3	4	6	8	11	840	2	2	2	0	1	0	0
56.11	10 4	0	2	2	2	4	6	8	>1000	0	0	2	0	0	0	0

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13. ABSTRACT

A test program was conducted on a 60-deg-slant, segmented wall, magnetohydrodynamic generator. The generator channel was 48 in. in length with an inside width of 2 in., and diverged from 4 in. in height at the channel inlet to 6 in. in height at the channel exit. The plasma was provided by a gaseous oxygen/RP-1 combustor with a Mach number 1.6 nozzle. The propellants were seeded with potassium hydroxide (KOH) dissolved in ethyl alcohol to produce a high ion concentration in the exhaust stream. The generated power was dissipated through a resistor load bank with a variety of parallel and series resistance configurations. Operating conditions were nominally as follows: combustor chamber pressure, 46 psia; KOH concentration, from 0 to 1.8 percent of total propellant weight flow; magnetic field, 20,000 gauss; and load bank resistance, from 0 to 61.5 ohms. Tabulations of combustor performance data and of the generator electrical data are presented.

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